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Manuals and Guides No. 1

Targeting dairy interventions in Kenya;
A guide for development planners, researchers and extension workers.

R. Ouma, L. Njoroge, D. Romney, P. Ochungo, S. Staal, and I. Baltenweck

Smallholder Dairy Project

The Smallholder Dairy Project (SDP) carried out research and development activities to support sustainable improvements to the livelihoods of poor Kenyans through their participation in the dairy sub-sector. SDP was jointly implemented by the Ministry of Livestock and Fisheries Development (MoLFD), the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI). The project was led by the Ministry with primary funding from the UK's Department for International Development (DFID). The three organizations worked with many collaborators, including government and regulatory bodies, the private sector and civil society organizations.

Key areas of SDP research and development activities were:
• Analysis of factors constraining the competitiveness of smallholder dairy farmers, including farm constraints, markets and infrastructure, and information services.
• Analysis of policies and institutions affecting the dairy sub-sector, and provision of resulting information to support planning needs of stakeholders and policy-makers in the dairy sub-sector.
• Analysis of social benefits of smallholder dairy production, including income, employment and child nutrition.
• Participatory development of improved dairy farm technologies, such as improved fodder crops and feeding strategies.
• Development of appropriate technologies and strategies for small scale milk and dairy product traders.
• Development of extension and training materials to support smallholder farmers and small milk traders, and the development agencies serving them.
• Spatial analysis of dairy systems for improved targeting of technology and investment.

By combining the research capacity of KARI and ILRI with the experience and networks of the Ministry, SDP provided high-quality and wide-ranging research information to support smallholder dairy farmers, market agents, stakeholders and policy-makers from 1997 until 2005.

Kenya Dairy Development Program

The Kenya Dairy Development Program (KDDP) is a USAID-funded programme implemented by Land O'Lakes in partnership with African Breeders Service Total Cattle Management, International Livestock Research Institute (ILRI) and World Wide Sires.
The programme focuses on promoting milk and dairy products through promotional campaigns to increase consumption of dairy products. KDDP also focuses on processors and entrepreneurs, where interventions lead to an improved cold chain, improved quality and new dairy products with increased handling capacity. For dairy producers, KDDP interventions improve animal production during dry seasons and develop smallholder business capacity.

For more information about KDDP contact:
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Targeting Dairy Interventions in Kenya

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Section 1

Introduction: Concepts, methods and rationale

Introduction

This easy-to-use guide to effective targeting of selected dairy interventions in Kenya is intended for use by anyone involved in dairy farming in the country, such as development planners, researchers, service providers, suppliers of dairy inputs and extension workers. The guide answers the question often faced by these workers: where is their proposed intervention most likely to be adopted?

Using a combination of Geographical Information Systems (GIS) mapping methods and economic regression techniques, this guide shows where and under what circumstances dairy technologies are most likely to succeed.

Structure of the guide

The guide is divided into three sections. The first section deals with concepts, rationale and methodologies for targeting dairy interventions. It also explains, with examples, how to use the guide.

The second section presents the targeting maps for various dairy interventions. A total of eleven dairy interventions are considered in this guide. For each, a map shows relative probability of adoption together with a description of the innovation and background information. Also presented are the socio-economic, biophysical and agro-climatic characteristics that predispose uptake of each intervention.

The third section presents some policy-relevant research results in three topical areas:
• Cost of milk production
• Evaluation and assessment of alternative milk preservation techniques
• Employment generation in the dairy marketing chain.

What is targeting of interventions?

Targeting of interventions involves the systematic identification of domains where the probability of adoption is high and where promotional efforts can most effectively be focused. Targeting can be based on various approaches, such as identification of sub-populations of people, but this guide is based on identification of geographical areas. It uses spatial data to predict the likelihood of adoption of innovations by individual decision makers, i.e. farmers.

Effective targeting by geographical area requires four key questions to be answered:
• Can the intervention work in this area?
• Is there demand for the intervention in this area?
• What is the probability of adoption in this area?
• If the intervention is adopted, what impact will be achieved?

Impact is created when the intervention solves existing significant constraints faced by the farmers or creates new opportunities, and thus contributes to enhanced productivity and profitability which can alleviate poverty – by providing cash income or improving household nutritional status. Potential uptake of innovation is expressed in the form of probabilities: where probability is estimated at 30%, it means that on average 30 out of every 100 farmers in the defined domain will adopt the intervention once it is disseminated.

Why targeting is important

Effective targeting increases the success rate of dairy development interventions. People involved in dissemination activities - whether from the public or private sectors - want to be assured that their efforts and investments in dissemination activities will result in adoption and create the required impact. In this guide, targeting matches selected dairy interventions with the geographical areas to which they are most suited and where impacts will be greatest.

Likelihood of adoption is affected by geo-spatial factors, such as annual precipitation and temperatures, human population density, and socio-economic factors, such as household incomes, labour availability, experience and education of the household head, size of land and market access amongst others. These socioeconomic factors (such as wealth, scale of operation, age of farmer, degree of intensification, ethnicity, or economic viability of enterprise) can be used to target better agricultural interventions and improve distribution of impacts. The inclusion of social and economic factors helps to addresses the questions of where interventions can make a major contribution to alleviating poverty in ways that are socially equitable, ecologically sound and economically efficient. For example, concentration of intensive dairying beyond a certain point can cause harmful nutrient loading and targeting can help create an appropriate balance of crop-dairy systems (Utiger et al., 2000, de Haan et al., 1997). Many development projects are applying these approaches for targeting pro-poor investments and other equity considerations: Baltenweck et al., (2005) for example, use spatial and non-spatial targeting approaches to introduce pro-poor approaches in a project funded by the International Fund for Agricultural Development (IFAD) in Kenya.

Approaches to targeting

Depending on the availability of data and information, two approaches to targeting are possible: observation-based and criteria-based.

Observation-based targeting

This involved observing where a particular innovation has been adopted, plotting these sites on a map and identifying which common characteristics the sites share. Targeting of the intervention can then be directed to other areas that share these same characteristics.
The method of observation based technology mapping has been described by (Staal et al., 2002) and follows these steps:

1. Household and other characteristics from survey data and GIS derived data are used in a statistical model (see logistic regression model described in appendix 1) to predict adoption of the dairy technology. This model identifies significant characteristics of adopting farmers and uses this to predict probability of adoption. NB: Traditional technology adoption models often use only survey-derived data for all variables, some of which are difficult to interpret and cannot be usefully mapped. Often representative numbers are used for variables such as district.

2. Having predicted the model with GIS and survey data, we predict a second model using only the significant GIS-derived variables, with all other survey factors held constant at their mean. The two models have been compared and found to be more or less the same in explanatory and predictive power. However, the second model, given its variable GIS data, can be used for spatial prediction of adoption.

3. This second model is mapped.

The following example illustrates how this can be done for adoption of Napier grass as a fodder crop.
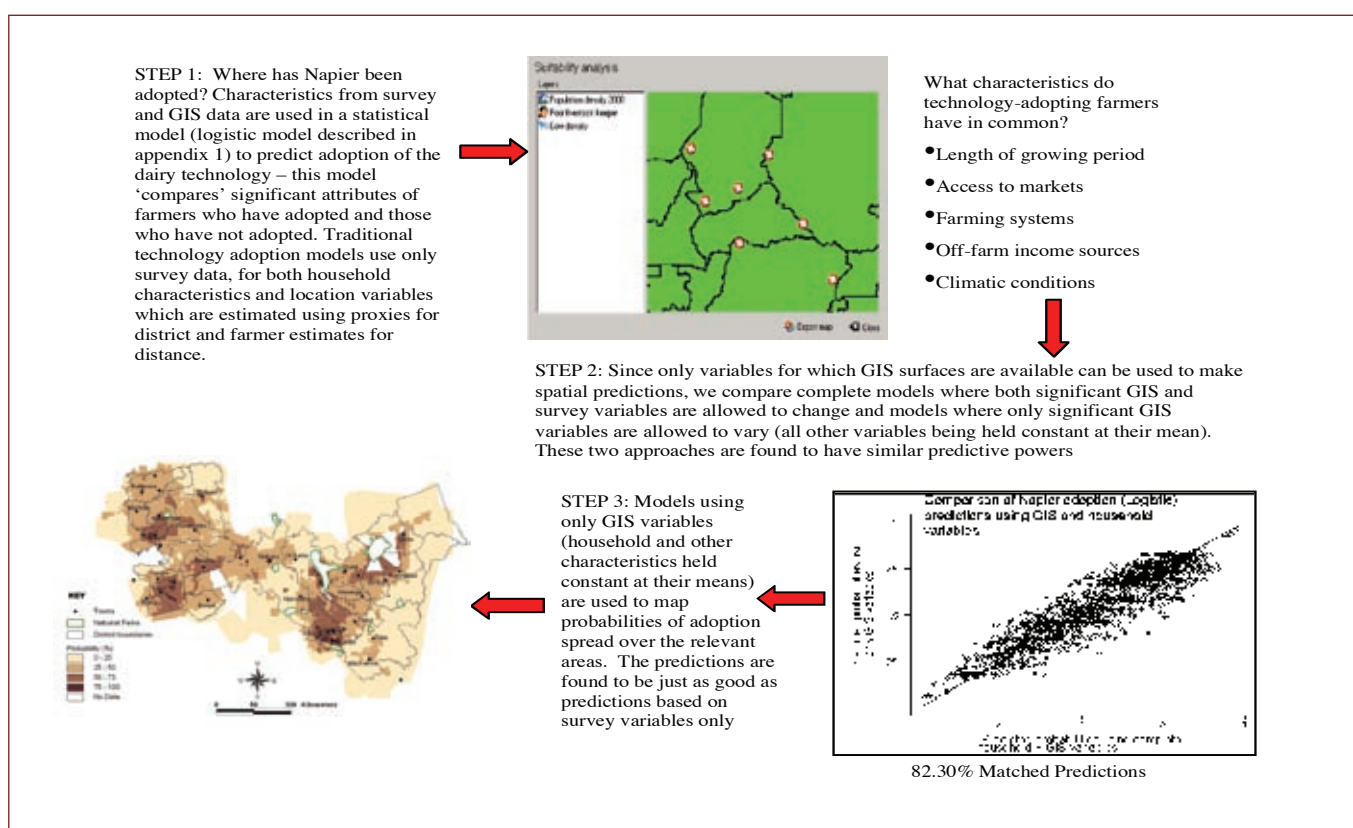
STEP 1: Where has Napier been adopted? Characteristics from survey and GIS data are used in a statistical model (logistic model described in appendix 1) to predict adoption of the dairy technology – this model 'compares' significant attributes of farmers who have adopted and those who have not adopted. Traditional technology adoption models use only survey data, for both household characteristics and location variables which are estimated using proxies for district and farmer estimates for distance.

What characteristics do technology-adopting farmers have in common?
- Length of growing period
- Access to markets
- Farming systems
- Off-farm income sources
- Climatic conditions

STEP 2: Since only variables for which GIS surfaces are available can be used to make spatial predictions, we compare complete models where both significant GIS and survey variables are allowed to change and models where only significant GIS variables are allowed to vary (all other variables being held constant at their mean). These two approaches are found to have similar predictive powers

STEP 3: Models using only GIS variables (household and other characteristics held constant at their means) are used to map probabilities of adoption spread over the relevant areas. The predictions are found to be just as good as predictions based on survey variables only

82.30% Matched Predictions

Figure 1: Napier grass adoption targeting using observations approach

(Adapted from Staal and Thornton, 2004)
The survey and GIS variables used in this guide are contained in Table 1

Criteria-based targeting

Unlike observation-based targeting, which relies on survey data (observations), this approach is based on expert opinion. The expert suggests parameters likely to be associated with uptake of the intervention, such as specific climate, market access and other conditions.

The area where each criterion exists is mapped and, by overlaying the individual layers, the area where all criteria are satisfied is identified: this is the area where (in the opinion of the experts) it is most likely that the intervention will be adopted. This area of confluence is refereed to as the 'recommendation domain' for adoption of the particular technology. This method can be used when detailed household survey data are not available but is entirely dependent on the quality of the expert opinion.

It is instructive to note that in targeting interventions, social and economic criteria are often much more critical to success of the intervention than natural and technical requirements; as a result some of the technologies targeted in this guide have taken these into consideration. Table 2 provides a list of the criteria used in developing maps in this guide.
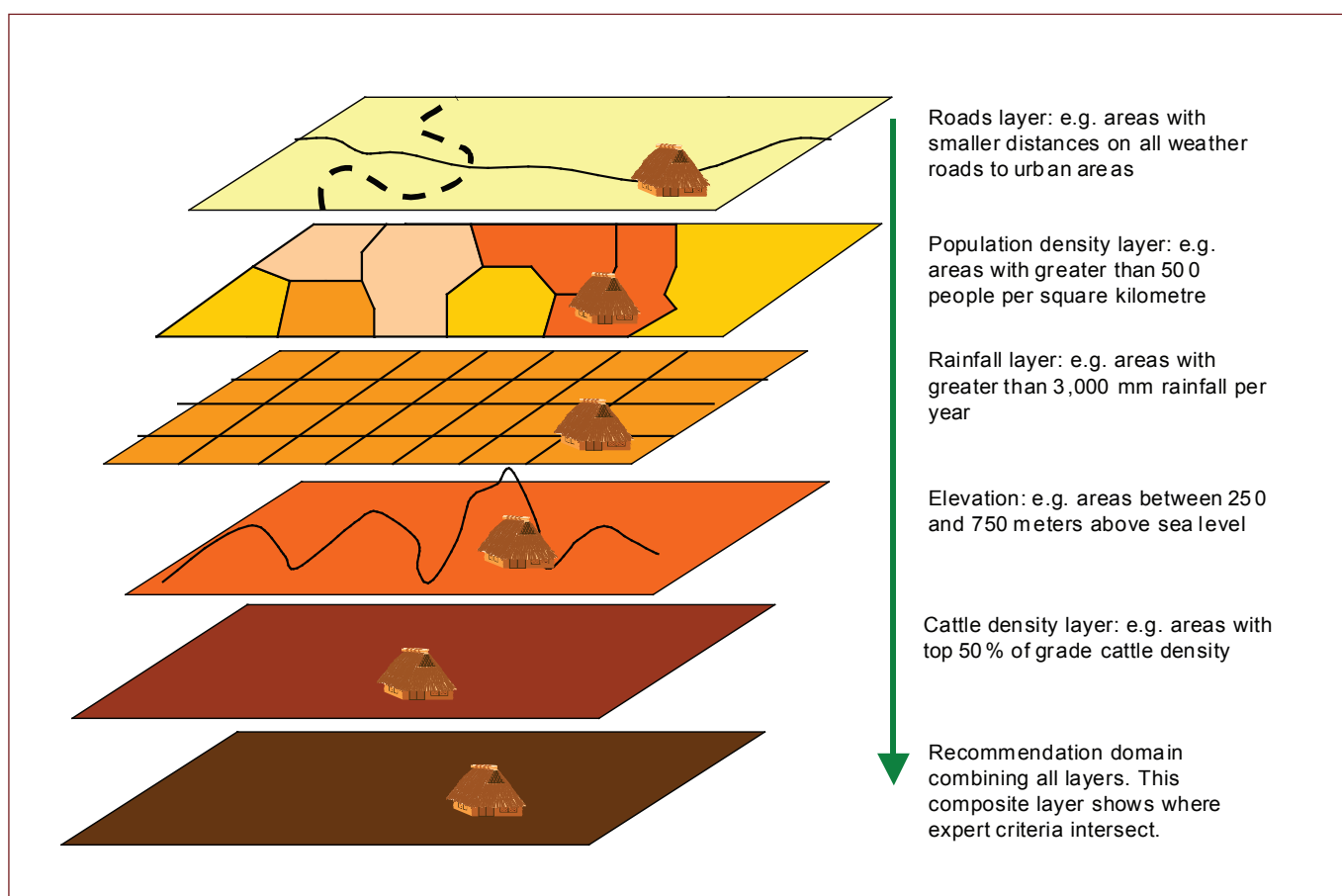
Roads layer: e.g. areas with smaller distances on all weather roads to urban areas

Population density layer: e.g. areas with greater than 500 people per square kilometre

Rainfall layer: e.g. areas with greater than 3,000 mm rainfall per year

Elevation: e.g. areas between 250 and 750 meters above sea level

Cattle density layer: e.g. areas with top 50% of grade cattle density

Recommendation domain combining all layers. This composite layer shows where expert criteria intersect.

Figure 2: How criteria layers are superimposed to create a targeting map
(Adapted from Staal and Thornton 2004)

Geographic Information Systems (GIS) layers

GIS combine layers of information about a place to give a better understanding of that place. The information could be about market access, demographics, agro-climatic, cattle densities, amongst others. Conceptually, superimposing one layer on another combines the information of the two layers, thus providing multiple information sets, for example, about access to market and demographic characteristics.

GIS analysis is rapidly becoming an important tool in assessing potential for technology use. There is no doubt that spatial factors represented as GIS layers can show key influences to adoption of dairy interventions. For example, rainfall has been found to be closely related to adoption of certain interventions, such as planted fodder and even keeping dairy cattle. In this targeting guide, GIS derived data was used either separately (in criteria-based targeting) or in combination with survey derived data (in observation-based targeting) to predict where the probability of adoption is highest. As observed by Staal et al., (2002), only the variables for which GIS layers are available can be used to make useful spatial predictions. Survey variables such as age of household head, experience or years of education, while important in determining adoption of technologies, do not lend easily to mapping.

Below we present some of the GIS layers used in the guide and briefly explain how they were generated and how we expect them to influence adoption of the different dairy interventions.
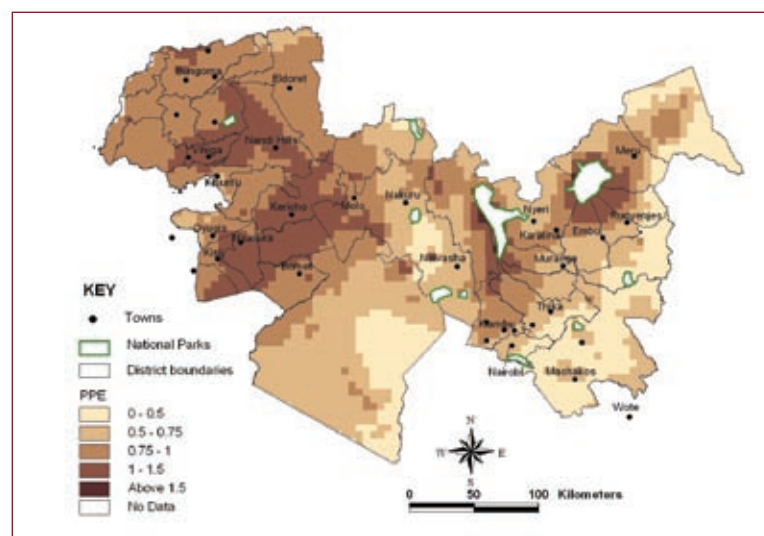
Below we present some of the GIS layers used in the guide and briefly explain how they were generated and how we expect them to influence adoption of the different dairy interventions.

Figure 3: Agro-climatic potential layer.

• Calculated as the ratio of precipitation over potential evapo-transpiration (PPE).
• For the Kenyan Highlands, the higher the PPE, the higher the potential for keeping dairy cattle. This is because higher PPE provides good conditions for growing forage, a key input in dairy production.
• High PPE is also mostly associated with high altitude and thus temperate climatic conditions suitable for rearing dairy cattle.
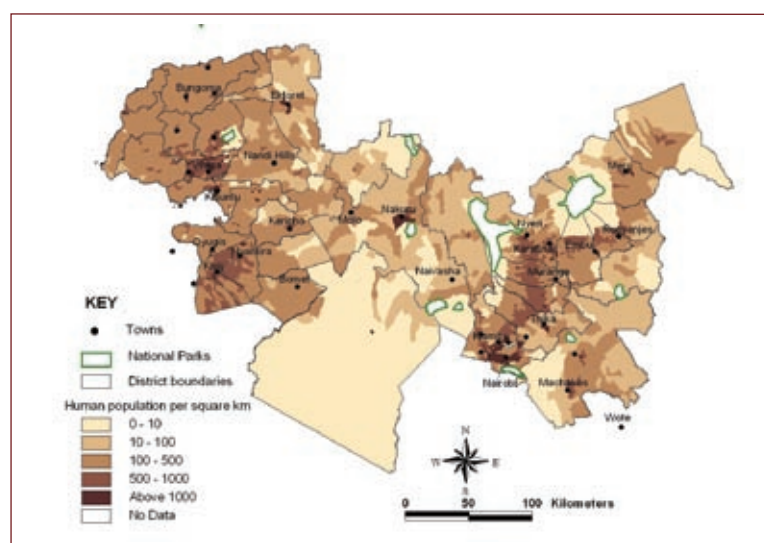

Figure 4: Human population density layer

• Human population density is computed as the number of persons per square kilometre. It is derived from the 1999 census data of the Kenya Central Bureau of Statistics. The data resolution is at sub-locational level.
• Areas of high human population density correspond to centres of high milk consumption where producers are likely to be able to sell their milk production locally. Also, population pressure is seen as a key driving factor for uptake of productivity enhancing interventions as high demand motivates farmers to increase their productivity.
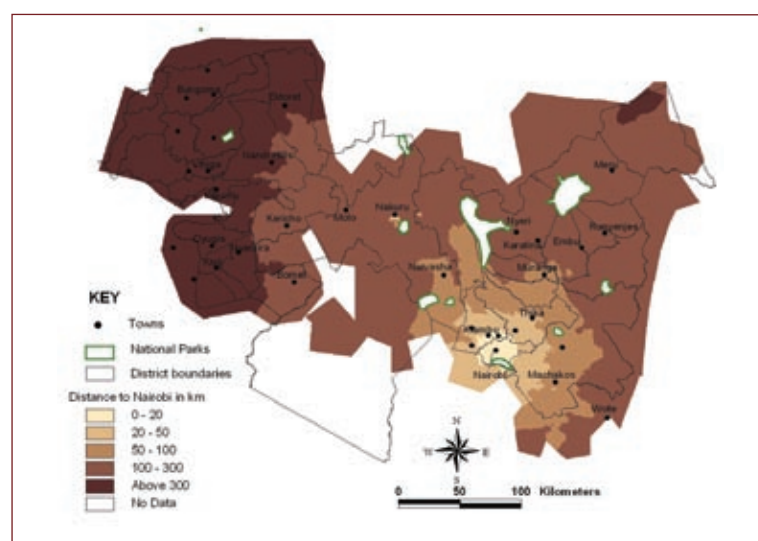
Figure 5: Total distance (km) to Nairobi layer

• Based on the Kenya highlands road network reflecting the road infrastructure in 2000.

• Nairobi, with approximately 2.14 million persons according to the 1999 census, is the largest metropolis in Kenya and constitutes the largest market for surplus milk produced in rural areas. Proximity to Nairobi is an indicator of good market access and also access to administrative and technical services based in the city.
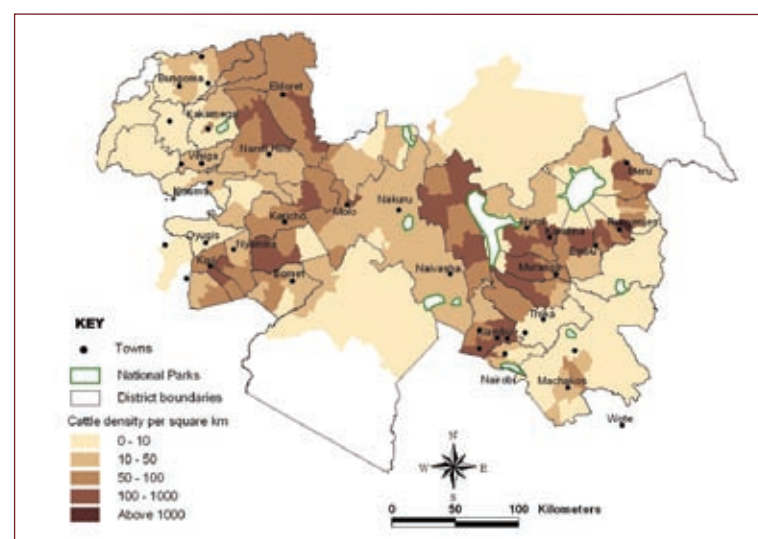

Figure 6: Cattle density layer

• This layer was created using the Department of Livestock Development's district annual reports for 1995. Divisional level data was used.

• The map clearly shows current areas of high dairy cattle concentration.

Table 1: List of variables used in observation based targeting

Variables	Data Source	Rationale of use
Sex of the household (hh) head	Survey	Male headed households are likely to have better access to information and services
Years of farming experience for the hh head	Survey	Longer farming experience predisposes farmer to better farming techniques through 'learning by doing'
Age of the household (hh) head	Survey	Age comes with experience and better management skills
Years of formal education for hh head	Survey	More formal education is likely to increase farmer capacity for management and for utilizing information
Landholding of hh in acres	Survey	Larger landholding implies more land available for cattle keeping but may reduce the need for concentrate feeding
Percentage of hhs in the sub-location with stated access to extension services	Survey	Availability of extension services implies support for the dairy enterprise in general
Percentage of hhs in the sub-location with stated access to formal milk outlets	Survey	Local availability of formal milk outlets implies reliable milk market, providing incentive to invest in dairy enterprise
Distance of the hh from the nearest qualified veterinary service provider	Survey	Greater distance to a vet implies decreased access to livestock services.
Mean human population density, 5 km radius	Survey	High population density is expected to correspond with high demand for milk and thus favourable local market; however it may imply pressure on land holdings
Annual precipitation/potential evapo-transpiration (PPE)	GIS	Higher PPE corresponds to more favourable agro-climatic conditions for dairy production
Total road distance (km) from hh to Nairobi	GIS	Greater distance to Nairobi implies reduced access to milk markets and livestock services, lower milk prices and higher input prices
Distance from homestead to a medium size urban centre on tarmac road	GIS	Greater distance to an urban centre implies reduced market access.
Tarmac road distance to nearest urban centre	GIS	Greater distance along main roads to urban centres is expected to reduce prices in milk markets, and raise prices and reduce availability of inputs and services
All-weather earth road distance to urban centre	GIS	Greater distance along secondary roads reduces milk prices while raising prices and reducing availability of inputs and services
Dry-weather only road distance to nearest urban centre	GIS	Greater distance along seasonal roads will reduce access to input and output markets, and increase seasonal risks

Table 2: Criteria used to map recommendation domains for interventions

GIS criteria layers	Basis for layer
Roads layer	This layer allows specification of criteria based on distance over given road types (all weather, tarmac, etc) to the specific urban centres, towns etc
Travel time layer	This layer allows experts to give limits on how long a farmer can travel to a market or nearby town using a specified means of transport for a technology to be considered viable.
Rainfall grid	The rainfall grid allows expert selection of areas on the basis of total annual rainfall or precipitation / evapo-transpiration (PPE) .
Population density layer	Allows identification of areas with certain specific population densities (people per square kilometer).
Improved cattle density layer	Usually expressed as percentage of total cattle population, this layer provides experts with option to select areas with relatively greater or lesser improved cattle densities.
Market access layer	While other layers (such as roads) can be used as proxies for market access, this layer is a simple average of total distance values weighted by population.
Household poverty layer	This layer provides percentages of households within given income brackets, such as the poverty line (US$1 a day).
Milk surplus (or deficit) layer	Surplus is excess of milk production over consumption in an area. Deficit is shortfall of milk production below consumption in an area.

Section 2

Dairy Interventions

Improved dairy cattle

Market-oriented dairy farming using exotic cattle started in Kenya almost a century ago when European settlers introduced dairy cattle breeds from their native countries. Crossbred cattle dairy production by Africans began in 1954 when a colonial policy paper, the Swynnerton Plan, allowed them for the first time to engage in commercial agriculture. Today it is estimated that Kenya has up to 6.7 million dairy cattle (SDP, 2005) and about 1.8 million households who rely on dairying. Significantly, thousands of jobs are created within the dairy milk marketing chains; these employment effects of dairying are discussed on page 32 .

Why improved dairy cattle?

• Improved dairy cattle produce on average 6-times as much milk per year as zebu cattle: 1,500 kg of milk per lactation compared to zebu which produce an average of 250 kg.

• Other productivity indicators, such as age at first calving and growth rate, are also superior compared to local zebu cattle.

• Improved cattle are more efficient in converting feed to milk.

• Improved dairy animals are also larger and therefore fetch higher prices when sold for meat.

• Improved dairy cattle are suited to intensive production systems where land is limited; they provide better returns to investments in the intensive production systems.

Factors used to predict probability of adoption of improved dairy cattle, derived from statistical analysis of survey and other spatial data, were:

• Agro-climatic potential, expressed as PPE: higher PPE associated with adoption.

• Total distance to Nairobi: closeness to Nairobi associated with adoption.

• Nearness to roads: closeness to roads associated with adoption.

• Education level of head of household: more years of education associated with adoption.

• Years of farming experience of head of household: more years of farming experience associated with adoption.
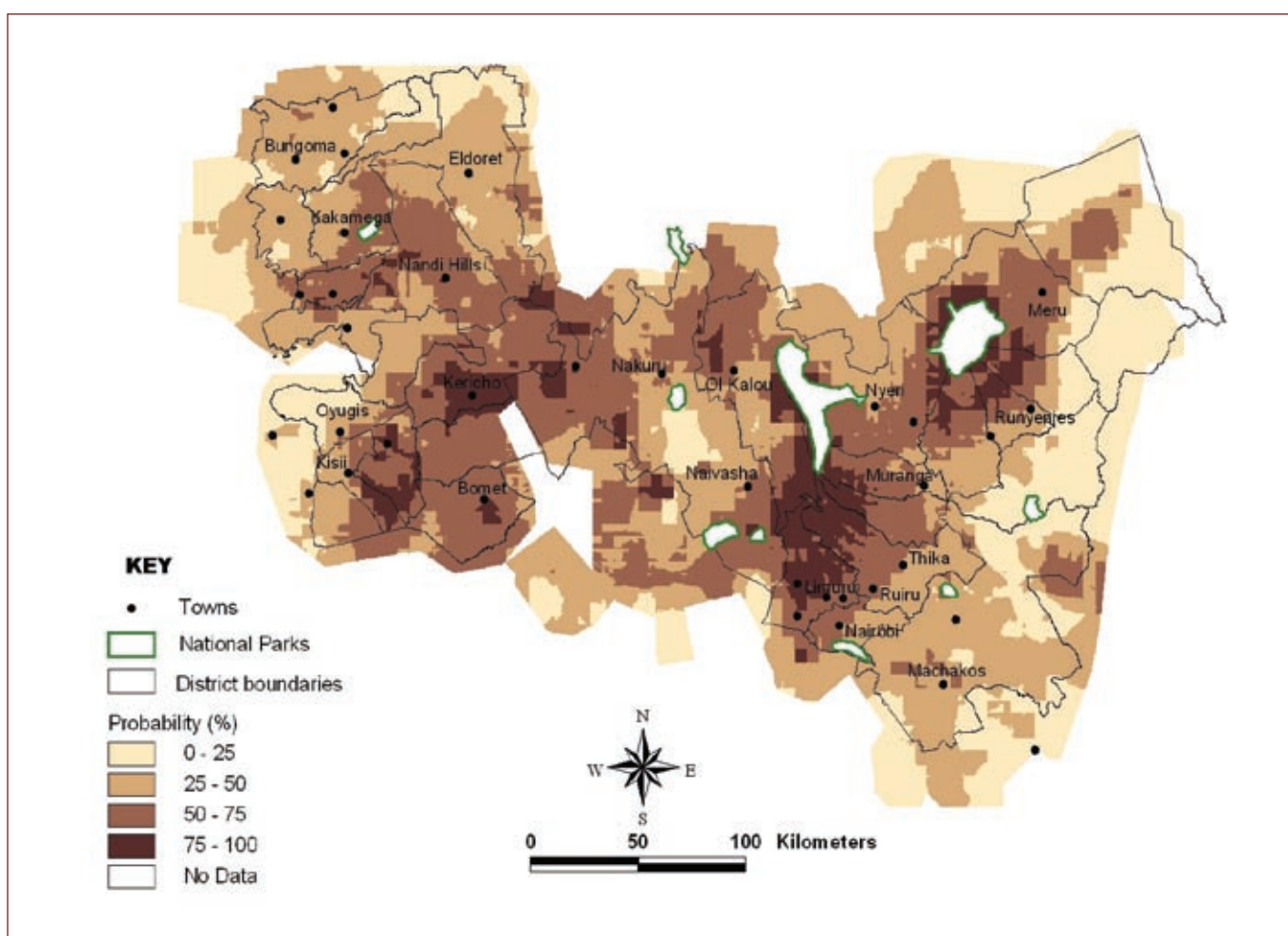
KEY

- • Towns
- ▭ National Parks
- ▭ District boundaries

Probability (%)
- 0 - 25
- 25 - 50
- 50 - 75
- 75 - 100
- No Data

Figure 7: Predicted probability of adoption of dairy cattle

Interpretation and discussion of the map

This map shows the predicted probabilities of adoption of improved dairy animals. It combines the spatial mapping of the factors predisposing adoption of improved dairy cattle: favourable climates, good market access, and experience/ exposure of the dairy farmer, to predict probability of adoption.

The different colours represent differences in predicted probabilities of adoption of the innovation: the darker the shading the higher the likelihood of adoption.

Low probability (lighter colours) implies a lower chance of adoption of improved dairy cattle because of unfavourable climate and/or socio-economic factors.

From the map, Kiambu is seen to show between 75% and 100% probability of adoption owing to the convergence of all major predisposing factors. In contrast, places such as Mbeere show less than 25% likelihood of adoption because they are further away from large, formal markets and have lower rainfalls.

Zero-grazing

In the Kenyan Highlands, two distinct feeding systems for dairy cattle can be distinguished: zero-grazing, also known as stall feeding, and open grazing. In some textbooks they are called intensive and extensive feeding systems, respectively. In between the zero-grazing and open grazing feeding systems, lies semi zero-grazing or semi-intensive feeding system which combines stall feeding and open grazing

In zero-grazing, cattle are confined in stalls and all their feed requirements are brought to them. In open grazing, cattle are kept on pasture where they obtain the largest proportion of their feed, often with some additional supplementation during milking. The choice of the feeding system is normally motivated by a desire to optimize the limiting resource. In areas of high population density, land tends to be the limiting factor whereas in open grazing labour is the limiting factor. Expenditure on purchased feeds and concentrates are higher in zero-grazing system than in open grazing.

Why zero-grazing system?

• Allows for optimal utilization of land in situations where land is a limiting factor. For example, in areas of high population density where farm size tends to be small.

• Intensive systems give higher output and productivity per cow or unit area of land.

• Zero-grazing reduces the number of pests (especially ticks and intestinal worms) since the animals do not graze on infested pastures.

• It reduces risk of damage to crops caused by straying cattle.

Factors used to predict probability of adoption of zero-grazing, derived from statistical analysis of survey and other spatial data were:

• Farm size: smaller farm size associated with adoption.
• Human population density: higher population densities associated with adoption.
• Total distance to Nairobi: closeness to Nairobi associated with adoption.
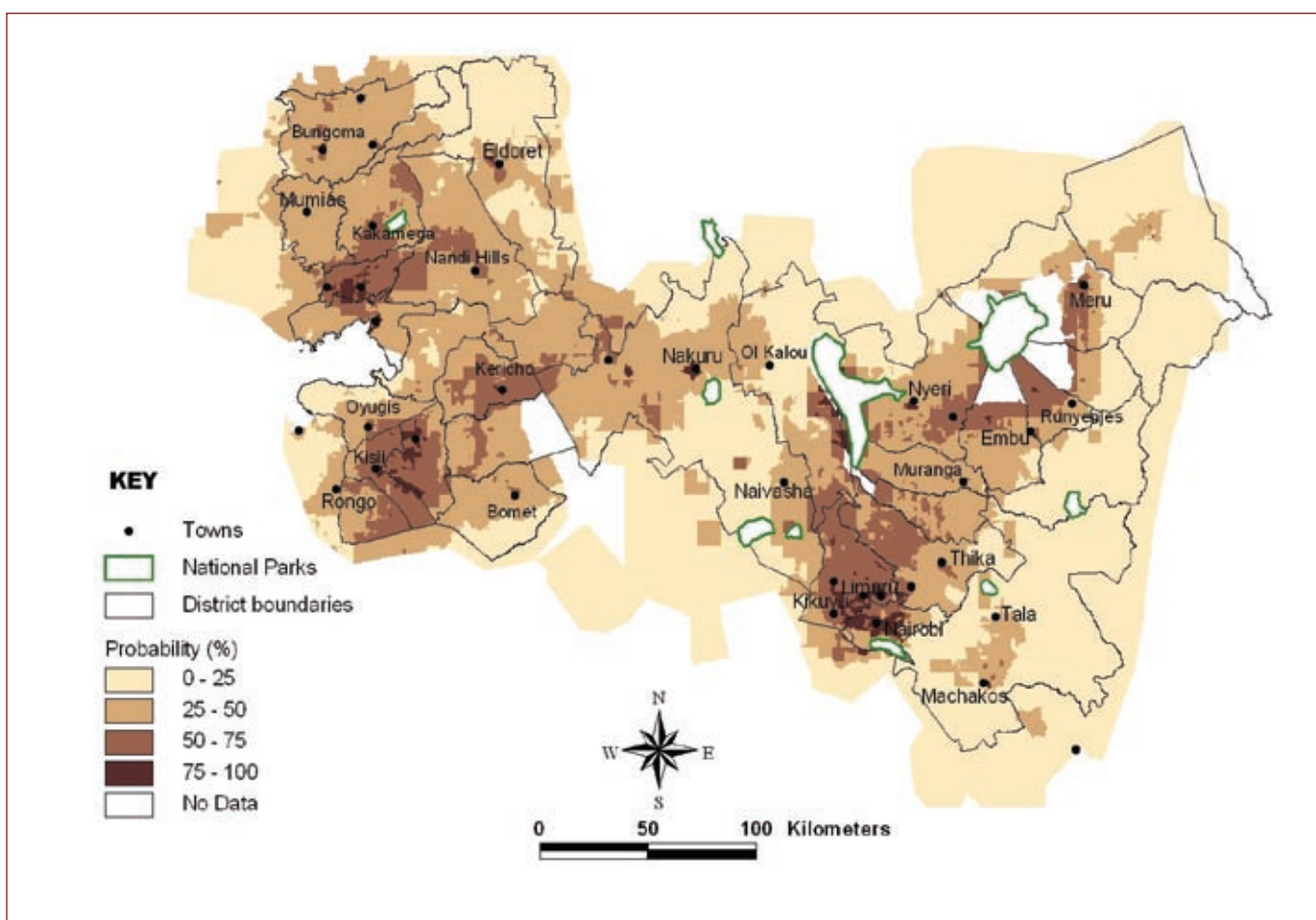• Agro-climatic potential, expressed as PPE: higher PPE associated with adoption.

Figure 8: Predicted probability of adoption of zero-grazing

Interpretation and discussion of the map

The darker the shading, the higher the probability of adoption of zero-grazing. Adoption of zero-grazing is largely driven by the density of human population suggesting that adoption of zero-grazing technology is a reaction to growing population pressure: variables such as population density, farm size and proximity to Nairobi all show significant correlation with adoption of zero-grazing.

Favourable climates, evidenced by higher precipitation, lead to higher adoption of zero-grazing but other agricultural enterprises compete for land in such high potential areas, pushing dairying towards greater intensification.

Highly populated areas in central Kenya, such as around Nairobi and parts of the Rift Valley, show the highest likelihoods of adoption of zero-grazing.

Concentrate feeding

Concentrates are energy, protein; fat or mineral supplements fed to dairy cattle and are used to supplement fibrous forages and fodder that constitute the basal diet. Many concentrates are by-products from cereal production but they also include by-products from other crops, such as oilseeds, as well as feeds derived from animal sources, such as meat and bone meal. Effective supplementary feeding of concentrates is critical to the success of all dairy farms.

The main factors influencing the response, in terms of increased milk production, to concentrate feeding are genetic potential for milk production, stage of lactation, feeding level in relation to milk production, heat stress, pasture availability and nutrient content, substitution rate of the concentrate for pasture, quality of concentrates. However, to justify using concentrates, the cost must at least be matched by increased milk production. The optimum amount of dietary energy and protein to maximise profits is therefore determined by the interaction of cow and feed factors, as well as feed costs and milk prices.

Overall in Kenya, less than 20% of the farmers use concentrates (Staal et al., 2001) and even this figure has been declining due to rising costs relative to prices paid out for milk. However, close to major towns the use of concentrates increases to as high as 70%, for instance in Kiambu district, (Staal et al. 1998) and reduces to less than 10% of the households in districts farther away from urban centres. Many farmers use small amounts of concentrates to relax the cows when milking and not really for increased milk production; we however do not consider this to be true adoption of concentrate feeding.

Adoption of concentrates is also affected by the quality of the concentrates available. The perception that manufactured animal feeds may be of questionable quality has been a recurring policy issue in Kenya (Muriuki et al., 2003)

Why concentrate feeding?

• To achieving high milk production

• Higher stocking rates are possible, increasing the income per hectare.

• The growth of heifers and cows that have not reached mature size is promoted. This increases their appetite and milk production in current and future lactations.

• Cows fed supplements maintain better body condition score when pasture availability is low. This increases their ability to reach their milk yield potential and helps reduce the time of their first oestrus after calving.

• Allows flexibility to increase milk production when milk prices are high.

• Appropriate supplementation can increase milk protein content when the energy intake from pasture is low.

Factors used to predict the probability of adoption of concentrate feeding, derived from statistical analysis of survey and other spatial data were:

• Increasing market access, as indicated by distances to urban centres: shorter distance associated with adoption.

• Total distance to Nairobi: closeness to Nairobi associated with adoption.

• Agro-climatic potential, expressed as PPE: higher PPE associated with adoption.

• Years of formal education and years of farming experience are some of the human capital (survey derived) variables influencing adoption trends; while acreage kept under maize was also an important factor in influencing the use of concentrates. See also Staal et al 2002.
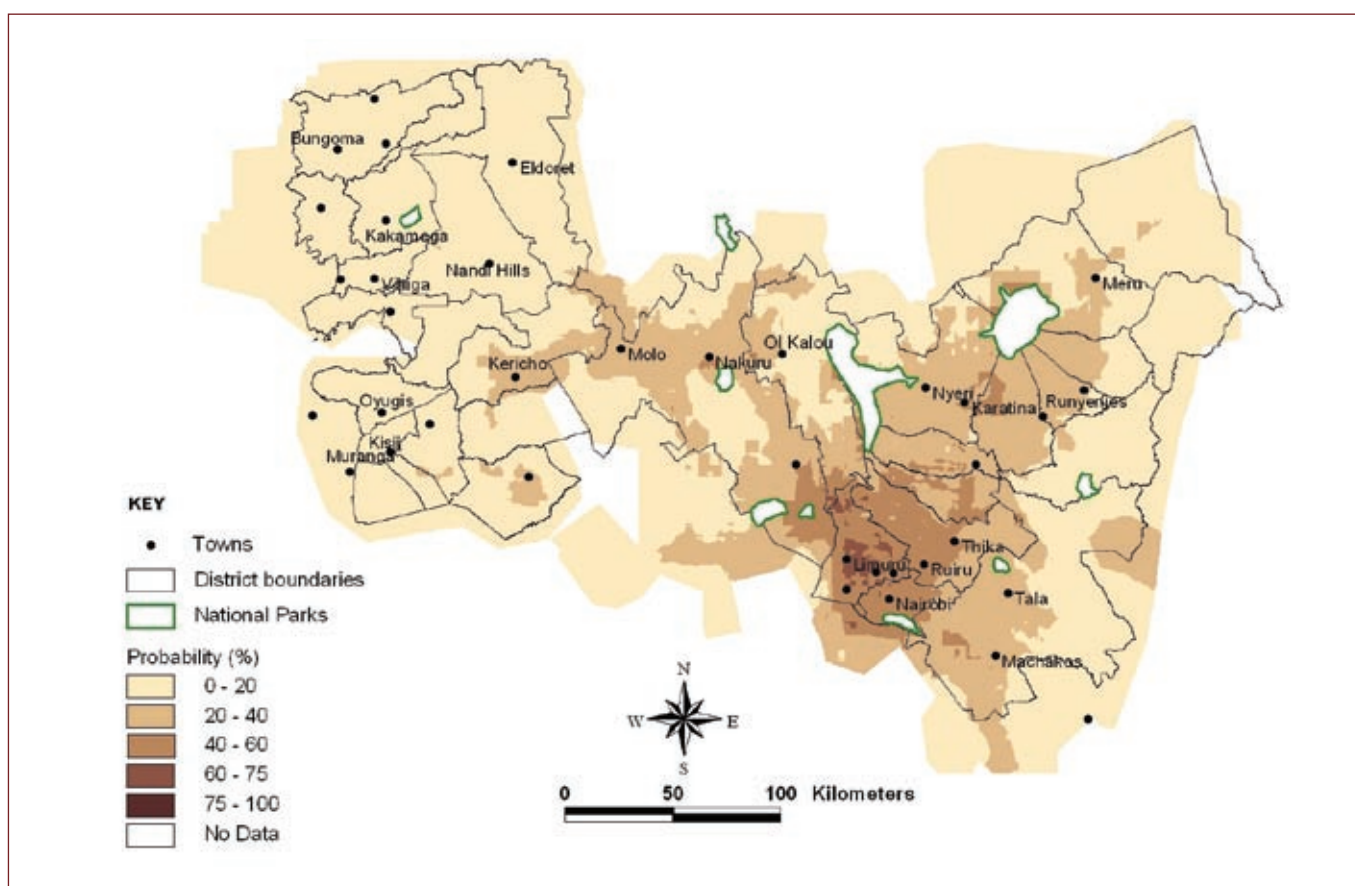

Figure 9: Predicted probability of adoption of concentrate feeding

Interpretation and discussion of the map

The darker shading corresponds to areas where probability of adoption of concentrate feeding is highest. From the map we can see that the use of concentrates is usually but not necessarily practiced in areas around towns. Market access is important: the shorter road distance to urban centres - proxy for good market access - are associated with use of concentrates.

Farmers who live in areas with high rainfall use more concentrates. This may be related to the presence of improved cattle in these areas: concentrates are normally fed only to improved cattle.

Napier grass

Napier grass (Pennisetum purpureum) is an improved fodder crop, especially important in cut-and-carry systems (zero-grazing), and can produce large quantities of forage. Napier grass is a fast growing, deeply rooted, perennial grass growing up to 4 metres tall that can spread by underground stems to form thick ground cover. Napier grass is best suited to high rainfall areas but it is relatively drought-tolerant and can also grow well in drier areas. It does not, however, grow well in waterlogged areas. It can be grown along with forage legumes, around field boundaries and along contour lines or terraces to help control erosion. Napier grass is best suited to low to medium altitudes, but can grow in a wide range of well drained soils. It is ready for harvest three to four months after planting and harvesting can be repeated every six to eight weeks for up to five years.

Yields depend on agro-ecological zone and management but on average Napier gives 12 to 25 tonnes per hectare of dry matter per year. Much higher yields are possible with application of fertiliser and better management, creating a possibility for surplus production which can be conserved for feeding in the dry season.

Why Napier grass?

• It is an improved high-yielding fodder crop.

• Produces large biomass per hectare compared to other forage crops.

• Adapted to different climatic conditions, from moderate to very high rainfall areas. However, not suited to very high altitudes because it is susceptible to frost.

• Can help controls maize stalk borer by trapping the ovipositing moths if planted around maize (the 'pull' component of the push- pull approach; Desmodium constitutes the 'push').

• Can prevent soil erosion and excessive run-off.

• It has deep roots, so it is fairly drought resistant.

• The tender, young leaves and stems are very palatable to livestock.

• Napier grass grows fast.

• Can remain productive for up to 5 years (it is a perennial crop) removing the need for annual replanting.

Factors used to predict probability of adoption of Napier grass, derived from statistical analysis of survey and other spatial data, were:

• Agro-climatic potential, expressed as PPE: higher PPE associated with adoption.
• Human population density: higher population densities associated with adoption.
• Greater market access represented by shorter distances to urban centres: farmers who are able to sell more milk are more likely to use Napier.
• Total distance to Nairobi: closeness to Nairobi associated with adoption.
• Educational level of head of household: more years of education associated with adoption.
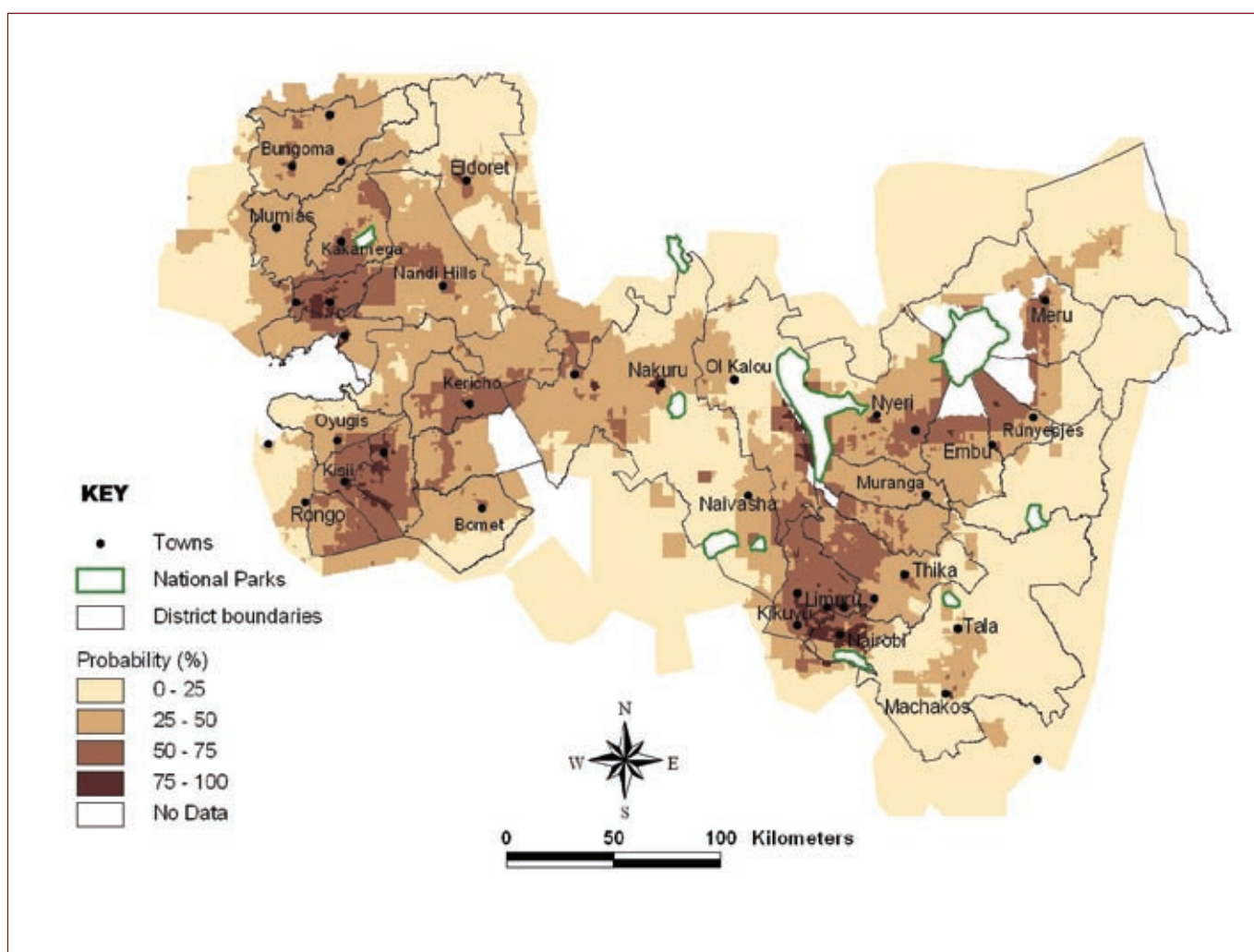
Figure 10: Predicted probability of adoption of Napier grass

Interpretation and discussion of the map

The darker the shading, the higher the probability of adoption of Napier grass. The darker areas receive high rainfall and have high human population density. Access to milk market, as indicated by presence of milk collection centres and proximity to Nairobi are also associated with adoption. In summary, adoption of Napier grass is more likely in intensive or intensifying market-oriented production systems.

Utilisation of crop residues

Crop residues are the portions of the harvested crop that remains after the grain or other primary product is removed. The most common crop residues used by the small-scale farmers in Kenya are:

• **maize stovers**	• **sugar cane tops**
• **green maize stalks**	• **bean and soybean hulls**
• **sweet potato vines**	• **crushed maize grain (rejects)**
• **banana pseudo-stems and leaves**	• **sunflower heads**
• **vegetable waste**	• **wheat, barley or oat straw**

These crop residues often make up a sizeable contribution to the total available feed supply, especially in the smallholder dairy production systems where land holdings are too small for fodder production. On Kenyan smallholdings, an estimated 40% of annual forage energy is derived from crop residues (Stotz, 1983). The quality of various crop residues is determined by the protein and energy or digestible dry matter (DDM) content of the particular residue. All crop residues possess their highest quality at the time of grain harvest and decline in quality the longer they remain in the field.

Two methods that can enhance the quality of residues are:
• harvest early to capture maximum residue quality.
• use of chemical treatments, primarily anhydrous ammonia, although the latter is rarely economically viable.

Why feed crop residues?

• Dry crop residues from cereals, such as maize or sorghum stover, are relatively easy to store for use in times of feed scarcity and often available in relatively large quantities. Although generally they have a low nutritive value they can support reasonable milk yields if fed with a supplement of high nutritive value, such as concentrates, legume fodder, etc.

• Some residues, such as sweet-potato vines or vegetable waste, although generally only available in small quantities can be of high nutritive value and can be used as supplements.

• Use of crop residues helps to create important synergies in crop-livestock farming systems; crop residues are fed to cattle, reducing the need for planted or purchased fodder, while manure from the cattle is used in the field to grow crops thus recycling nutrient and helping to maintain soil fertility. This ensures that there are multiple benefits and cost savings from each enterprise.

Factors that increased the likelihood of adoption of crop residues derived from statistical analysis of survey and other spatial data, were:

• Total distance to Nairobi: closeness to Nairobi associated with adoption.
• Agro-climatic potential, expressed as PPE: higher PPE associated with adoption.
• Human population density: higher population densities associated with adoption.
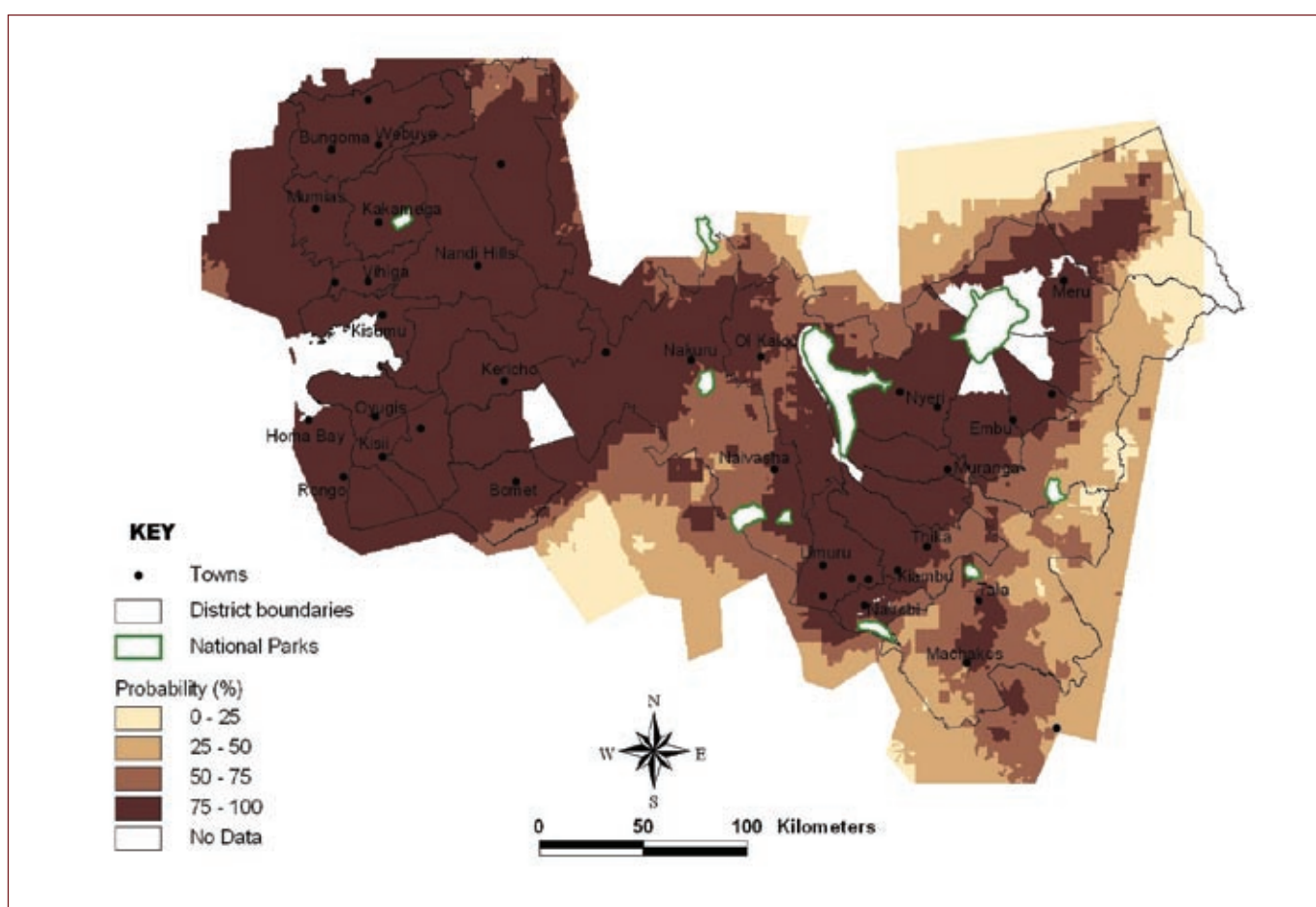
Figure 11: Predicted probability of adoption of feeding crop residues

Interpretation and discussion of the map

The darker the shading, the higher the probability that feeding of crop residues will be adopted. Factors associated with feeding crop residues include high rainfall and factors associated with market access. High rainfall areas are normally heavily populated: land holdings in such areas tend to be small, increasing the need to utilise all available feed resources, including crop residues.

Forage legumes

Forage legumes are important in the smallholder farming systems in Kenya because they are high in protein and, due to their ability to fix atmospheric nitrogen, can also improve soil fertility.

Research estimates (Staal et al., 2001) show that average milk yields per cow are below the genetic potential (approximately 1500 kg per lactation for improved cattle). This can be attributed in part to lack of adequate quality feed. Napier grass and cereal by-products, which commonly form the bulk of roughage for dairy cows, are generally low in crude protein, especially so during the dry season. Commercial protein sources that could supplement these roughages are too expensive for many smallholder dairy farmers to afford on a regular basis and in adequate amounts (FAO, 1985; Valk, 1990).

Production and utilisation of forage legumes is one of the low-cost methods for improving both the quantity and quality of livestock feeds on smallholder farms. The legumes can also concurrently enhance soil fertility for companion fodder grasses and subsequent cereal crops (Tothill, 1986, Mwangi et al., 1998) thereby reducing the cost of livestock feed and crop production for the resource poor farmer.

Why forage legumes?

• Forage legume crops are high in protein and can be used to supplement diets based on low-protein basal forages

• Forage legumes can fix atmospheric nitrogen; this leads to improved soil fertility, enhanced forage and mulching quality.

• Legumes can reduce the rate of decline of soil fertility, or even enhance crop yields, and can also reduce the length of the fallow period.

Criteria for predicting likelihood of adoption of Desmodium and Calliandra, derived from expert opinion and spatial data:

• Rainfall greater than 900mm per year
• Elevation between 250 and 750 meters above sea-level
• Human population density greater than 250 persons per km2
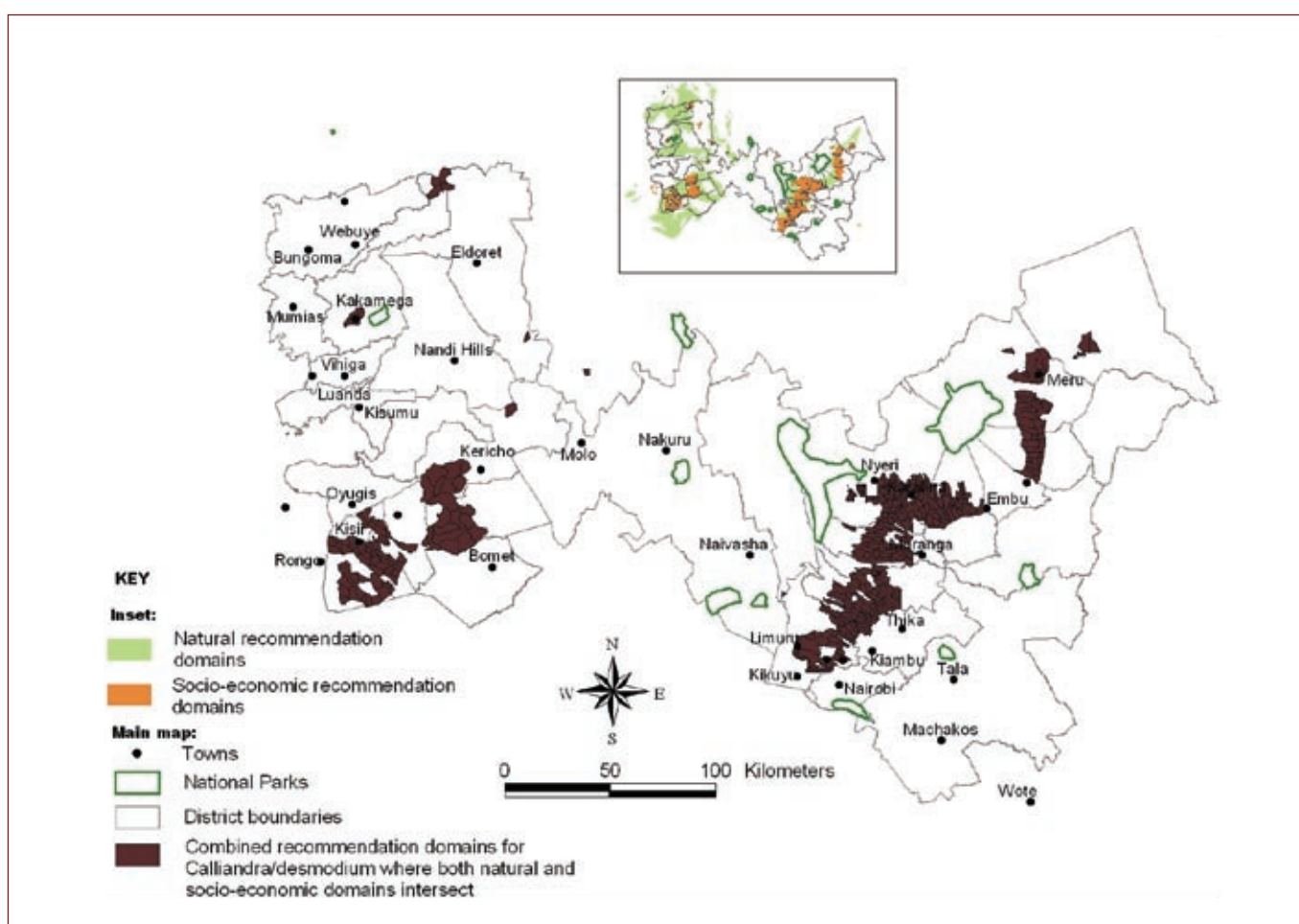• Improved cattle density greater than 50 cattle per km2

Figure 12: Criteria for natural and socio-economic potential for Desmodium and Calliandra

Interpretation and Discussion of the Map

The dark brown colour shows areas most suited to growing Desmodium and Calliandra. These are areas where the natural and socio-economic recommendation criteria combine to create optimal conditions for growing Desmodium or Calliandra. Dissemination should target these areas. The smaller map at the top-right corner shows the way the natural and socio-economic domains overlap and the areas where each of the domains is met -

In this map we show that for adoption of forage legumes, technical requirements may not be sufficient and socioeconomic criteria need to be considered as well. For example, a large part of Western Kenya meets all the natural criteria but not the socio-economic criteria, and uptake of these technologies in this region may therefore require greater effort.

Silage making

Forages can be conserved by either ensiling or hay making. In this guide, the focus will be on silage making.

Silage is the material produced by controlled fermentation of chopped crop residues or forages with high moisture contents. The purpose is to preserve forages through natural fermentation by achieving anaerobic conditions. The ideal characteristics of material for silage preservation are: an adequate level of fermentable substrate (8-10% of DM) in the form of water soluble carbohydrate (WSC) and a dry matter (DM) content above 200g/kg. The moisture content should be 60-70 per cent and the pH below 4.2 (acid) for wet crops and below 4.8 for wilted silages (Lukuyu et al., 2006. In Kenya, Napier grass, sorghum, maize and sugarcane tops can all be made into silage.

In Kenya, the common procedures of ensiling include the use of trench silos and plastic silos. A trench silo is generally built underground, or semi-underground, with two solid walls. Advantages of the trench silo include ease of management and mechanization, e.g., where available a tractor can be driven on top from one side to the other for compaction purposes. Compaction may also be achieved by applying other heavy loads or items. After compaction, it is covered with a plastic sheet pressed down with soil to maintain anaerobic conditions. In the plastic silo, plastic sheets or bags are used. These are filled with the ensiling materials and then compacted by trampling. The advantages of plastic silos are their low cost and the fact that they can be moved as needed.

Why silage making?

• Feed conservation, such as silage making, eases the serious feed shortages experienced in the dry season

• With adequate feed available year-round, animals remain in good condition

• Advantage can be taken of the higher milk price in the dry season

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Criteria-based targeting was used to predict where uptake of silage making is most likely to be successful. The criteria used include, high density of dairy cattle and appropriate agro-climatic conditions for producing feeds. However, because of the diversity of crops that could be ensiled, and therefore the wide range of climatic adaptability that they collectively allow, climate is not a major limitation. Areas with at least 900mm per annum of rainfall would be suitable for forage production. In addition, access to market is seen as a predisposing factor, with better access corresponding to higher chances that dissemination effort will succeed. Another factor that would affect adoption or non-adoption of feed conservation technology is the income level of the household. Adoption of this innovation entails outlay of cash (to buy polythene bags or dig the pit silo) and this would preclude poor households from adopting. The criteria used are summarised overleaf.

[1] *Tractors are used on rental basis by significant number of "small" farmers especially in Rift Valley.*

Criteria for predicting likelihood of adoption of silage making, derived from expert opinion and spatial data:

• High density of improved dairy cattle: top 50% of dairy cattle density
• Medium human population density: between 25% and 75% of range
• Area close to a road: closest 50%
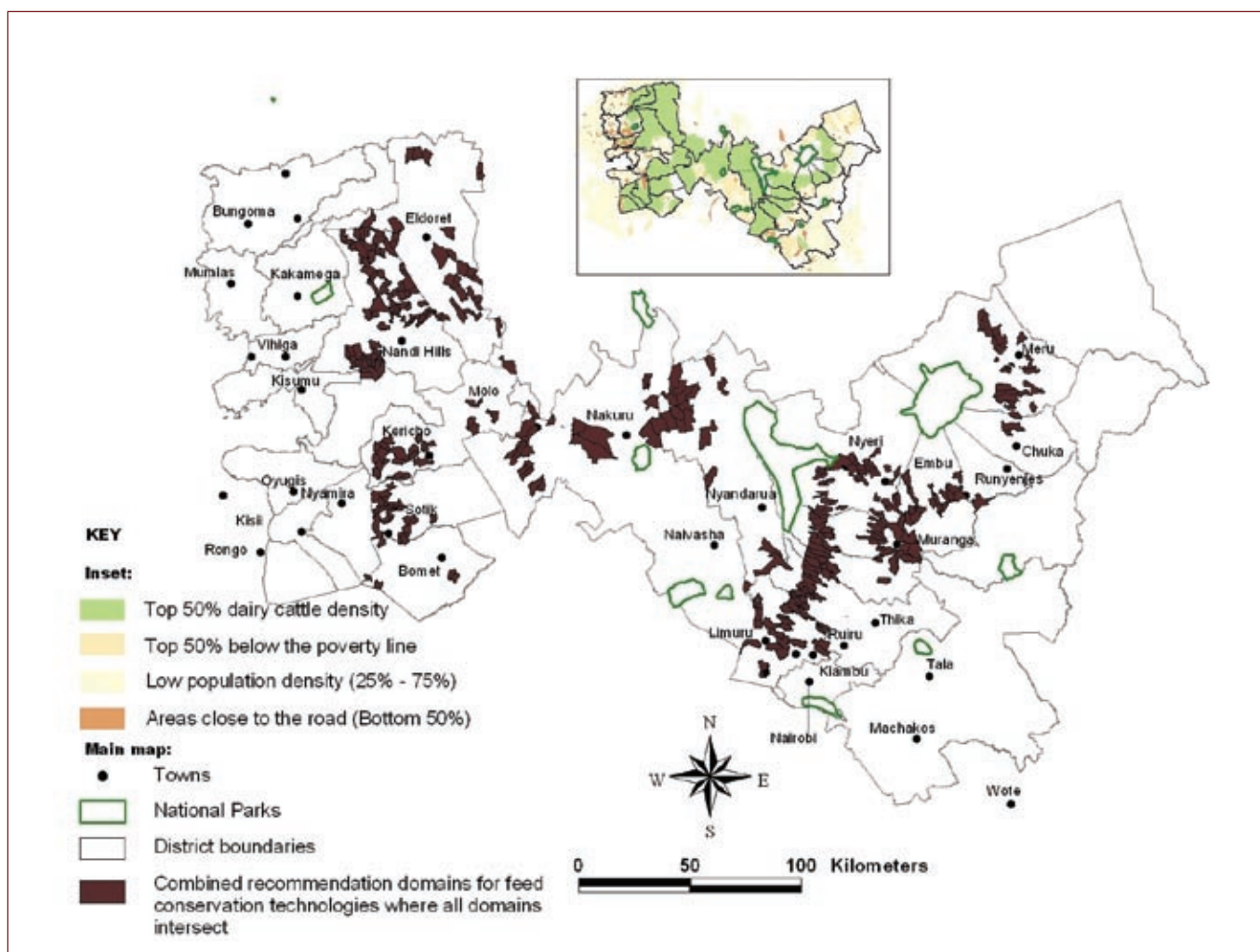• Relatively less areas: top 50% richest locations among those living below the poverty line.

Figure 13: Combined domains for targeting feed conservation technology

Interpretation and discussion of the map

The dark brown colour represents areas best adapted for uptake of silage making – this is the areas where all four criteria converge. These include most areas in Central Province and other districts around Mount Kenya, such as Meru and Embu, as well as some districts in central and north Rift Valley, for example, Kericho, Molo, and areas adjoining Eldoret.

Acaricide use

An acaricide is a chemical that kills ticks. The word is derived from Latin acarus, a mite and cide, kill. Acaricide are developed from different chemical classes. In the early 20th century arsenic, in the form of arsenic trioxide, was the only acaricide available. However, later organophosphorous compounds and carbonates were introduced and more recently amitraz and synthetic pyrethroids have become available.

Use of acaricides has a number of inherent problems: development of resistance by ticks; environmental pollution; cost; and creation of enzootically unstable disease situations. However, in Kenya and other countries where tick and tick-borne diseases, such as ECF, cause economically significant losses, use of acaricide will continue well into the future.

In the past, most acaricides have been used in plunge dips but other methods, especially hand spraying, are now popular with smallholders.

Why use acaricides?

• Tick infestation and tick borne diseases causes economically significant losses to livestock keepers.

• SDP surveys have shown (Staal et al., 2002) that of every 100 diseases reported by smallholder dairy farmers in Kenya, on average 21 were ECF, a further 16 other tick-borne diseases (TBDs); in total 37% of reported diseases were TBDs.

• Mortality rates from ECF infections are high.

• Treatment cost of ECF cases far outweighs cost of prevention with acaricide.

• When properly used, acaricide provide effective control of ticks, and thus the tick-borne diseases that they transmit.

Factors that increased the likelihood of adoption of acaricide use derived from statistical analysis of survey and other spatial data, were:

• Type of production system: more likely where open-grazing was practiced as opposed to zero-grazing. In fact, stall-fed cattle are less susceptible to ticks borne diseases as they are confined.
• Total distance to Nairobi: adoption is associated with increased distance from Nairobi.
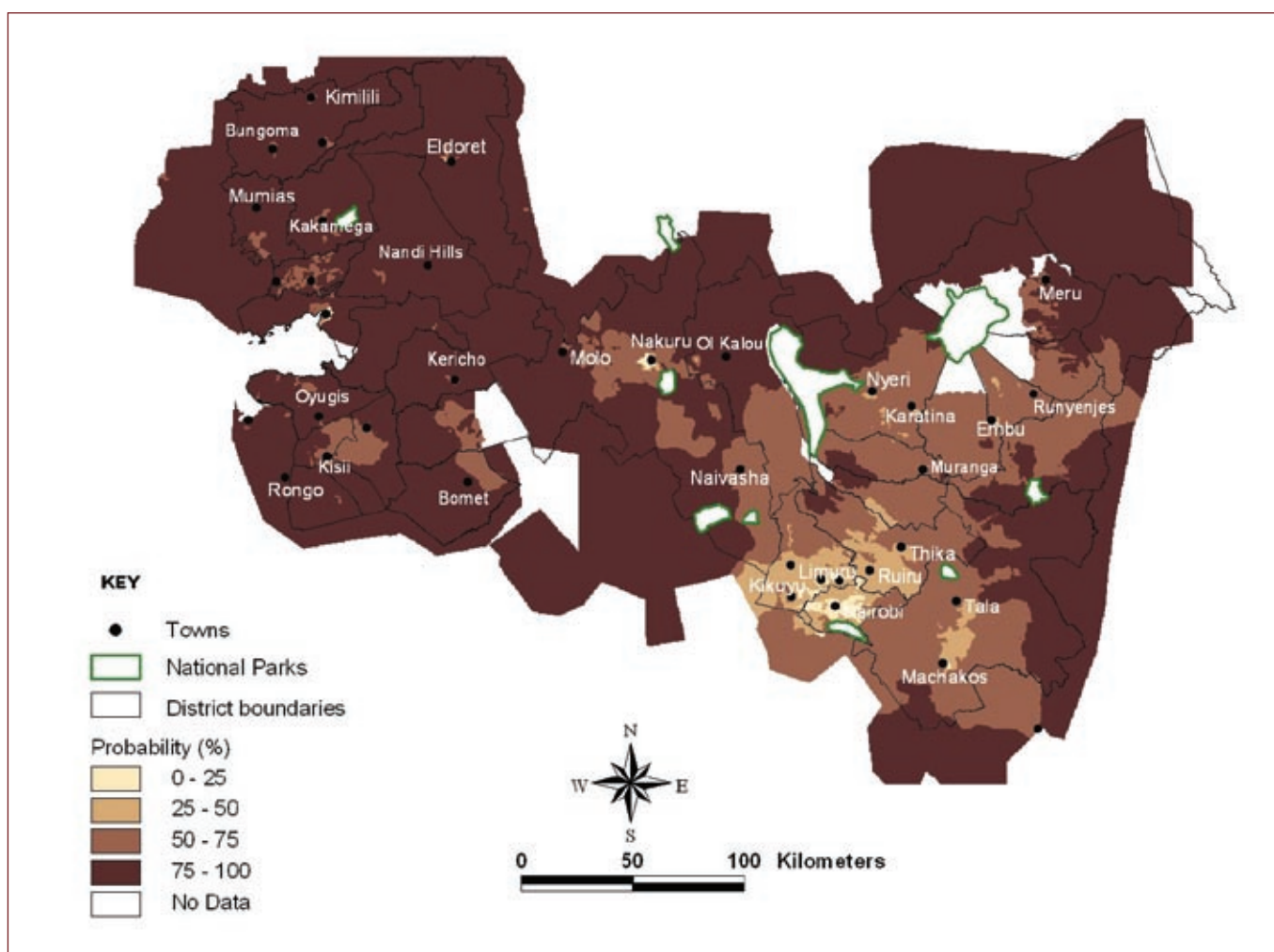
Figure 14: Predicted probability of acaricide adoption

Interpretation and discussion of the map

The areas on the map shaded darkest correspond to areas where probability of adoption of acaricide is highest. In these areas, challenge from ticks and tick-borne diseases is likely to be high. The dominant factor associated with a high probability of acaricide adoption is production system; predicted probability of adoption is high for all areas where dairy cattle are kept with the exception of areas like Kiambu district where the dairy system is predominantly zero-grazing.

Artificial Insemination

To get a cow pregnant one can either use artificial insemination (AI) or natural service, that is using a bull. AI involves the use of semen that has been collected from selected bulls, tested for diseases and stored in individual doses at low temperature in liquid nitrogen. Mainly through the use of AI, Kenya has managed to upgrade and expand the national dairy herd population from about 300, 000 in the mid 1960s to around 6.7 million animals today.

Prior to the privatization of AI service provision in the early 1990s, the government ran daily rounds of insemination in most rural areas. Inseminators passed through a fixed route each day to serve the animals brought by farmers to roadside cattle crushes. With the liberalization of AI provision in 1992, private practitioners who operate an 'on call' service emerged. Most farmers now have to contact the inseminator directly, by messenger or phone, and response is sometimes slow. In addition, the cost has increased dramatically from KSh 1 per insemination at the height of subsidization in 1971 to between KSh 580 and KSh 1000 for locally produced semen, and well over KSh 1,000 for imported semen.

- **Why AI?**

  - Leads to faster genetic improvement (or upgrading) of the local herd.

  - Ensures widespread access to genetically superior sires.

  - Even after death of sire, semen can still be used.

  - Rapid proof of quality of sires because with AI many offspring are produced in a short period.

  - The desired bull may be a great distance away; the semen can be quickly transported, saving time and money.

  - Minimizes sexually transmitted diseases, e.g. brucellosis.

  - Semen for AI is usually drawn from proven sires and thus superior phenotypic characteristics are transmitted to the next generation.

Factors that increased the likelihood of adoption of AI, derived from statistical analysis of survey and other spatial data, were:
- Increased market access: this is measured by total road distance (km) from homestead to the nearest urban centre. The shorter this distance greater the likelihood of adoption.
- Educational level of head of household: more years of education associated with adoption.
- Agro-climatic potential, expressed as PPE: higher PPE associated with adoption.
- Total distance to Nairobi: adoption is associated with decreased distance from Nairobi.
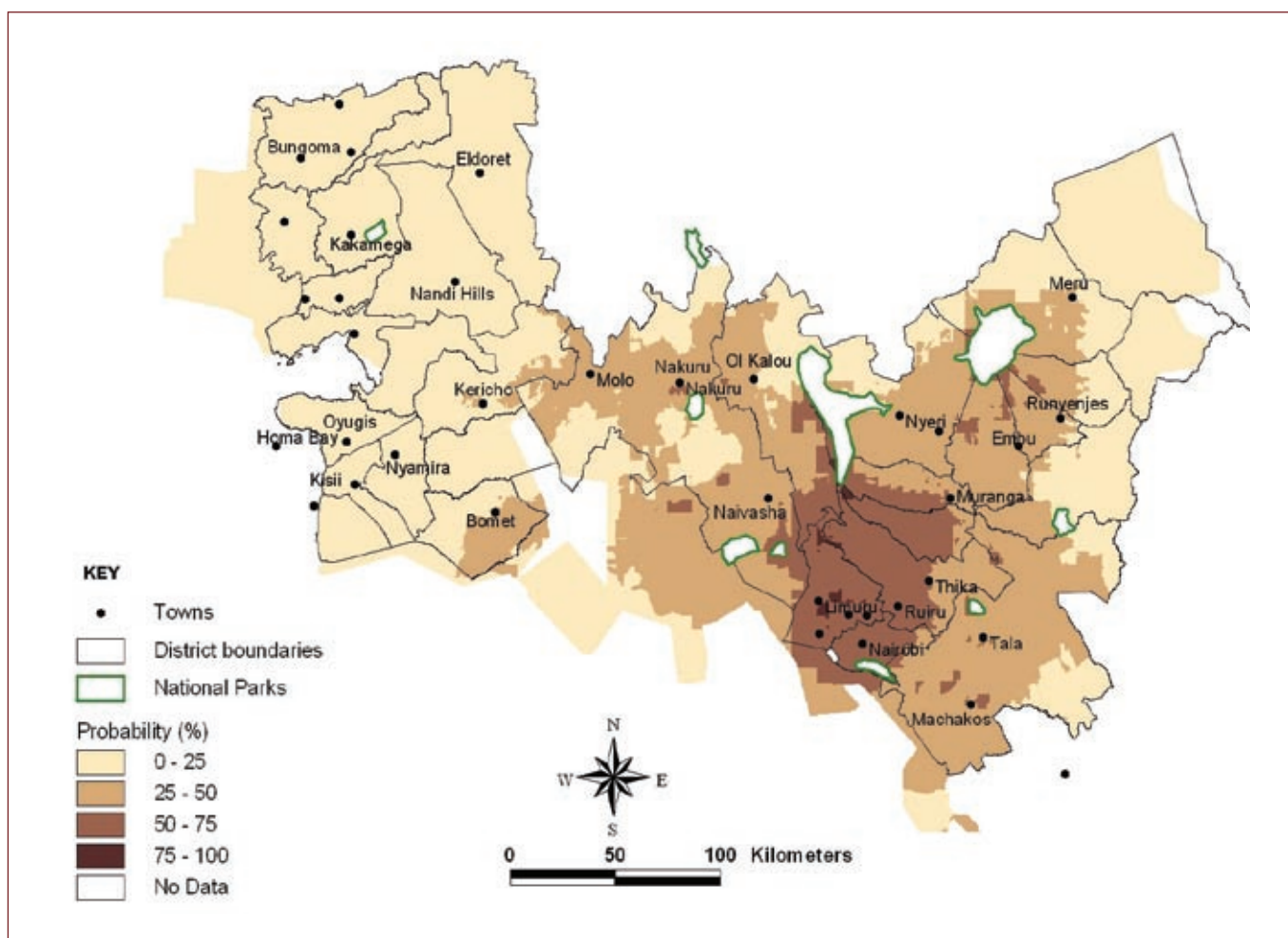
Figure 15: Predicted probability of adoption of AI

Interpretation and discussion of the map

Darker shading shows areas where there is a higher likelihood of farmers using AI technology, such as Kiambu and surrounding areas. From the map, it is evident that adoption of AI technology is most prevalent in the districts located in Central Kenya. Adoption is relatively lower in Western Province and most areas in North Rift despite indicators, like numbers of dairy cattle and agro-climatic potential, pointing to high potential for AI adoption. Historical non use and cultural biases are some of the reasons that may be responsible for this discrepancy.

Dairy co-operatives

A cooperative is a legal entity owned by its members that usually serves to bring together and exploit the strengths of its individual members in the pursuit of an economic activity. Cooperatives are able to exploit economies of scale and enhance bargaining power when dealing with buyers and suppliers. The primary function of a dairy cooperative, at least in the Kenyan context, is to procure milk from farmers, bulk and standardize it and send it to the market. Some cooperatives have adopted vertical integration strategies and are also engaged in milk processing and distribution. Other peripheral but important activities of a cooperative include provision of extension services, such as breeding (artificial insemination) and animal health services, including vaccination and operation of mobile clinics.

Dairy cooperatives should be located where dairy cattle and human population density is high. Dairy co-ops will have greatest impact in areas with surplus milk. They are, however, most needed when this surplus milk is in areas with poor market access. In areas where the milk surplus is in areas with good market access, dairy cooperatives can still perform well but there will be a greater choice of alternative marketing channels.

Why dairy cooperatives?

• Effective and efficient way of marketing milk. The cooperative takes the responsibility for collecting and bulking the milk, transporting and selling it on behalf of the members. This function is very important because marketing is a major problem in dairy development.

• Increases bargaining power when negotiating with suppliers and buyers.

• Allows for pulling together of economic resources and thus creating synergies otherwise not available if each member was to act on his/her own behalf.

Criteria for predicting likelihood of adoption of dairy cooperatives, derived from expert opinion and spatial data:

• Areas either far away, or very close to a major consumption centre; In areas far away from urban centres cooperatives pool resources that overcome marketing constraints imposed by distance and poor infrastructure. On the other hand, cooperatives nearer to large consumption centres make it easier for farmers to realise economies of scale and counter competition from other players.
• Milk surplus is calculated as the excess of milk production over consumption in an area. Surplus milk creates the necessity for marketing cooperatives.
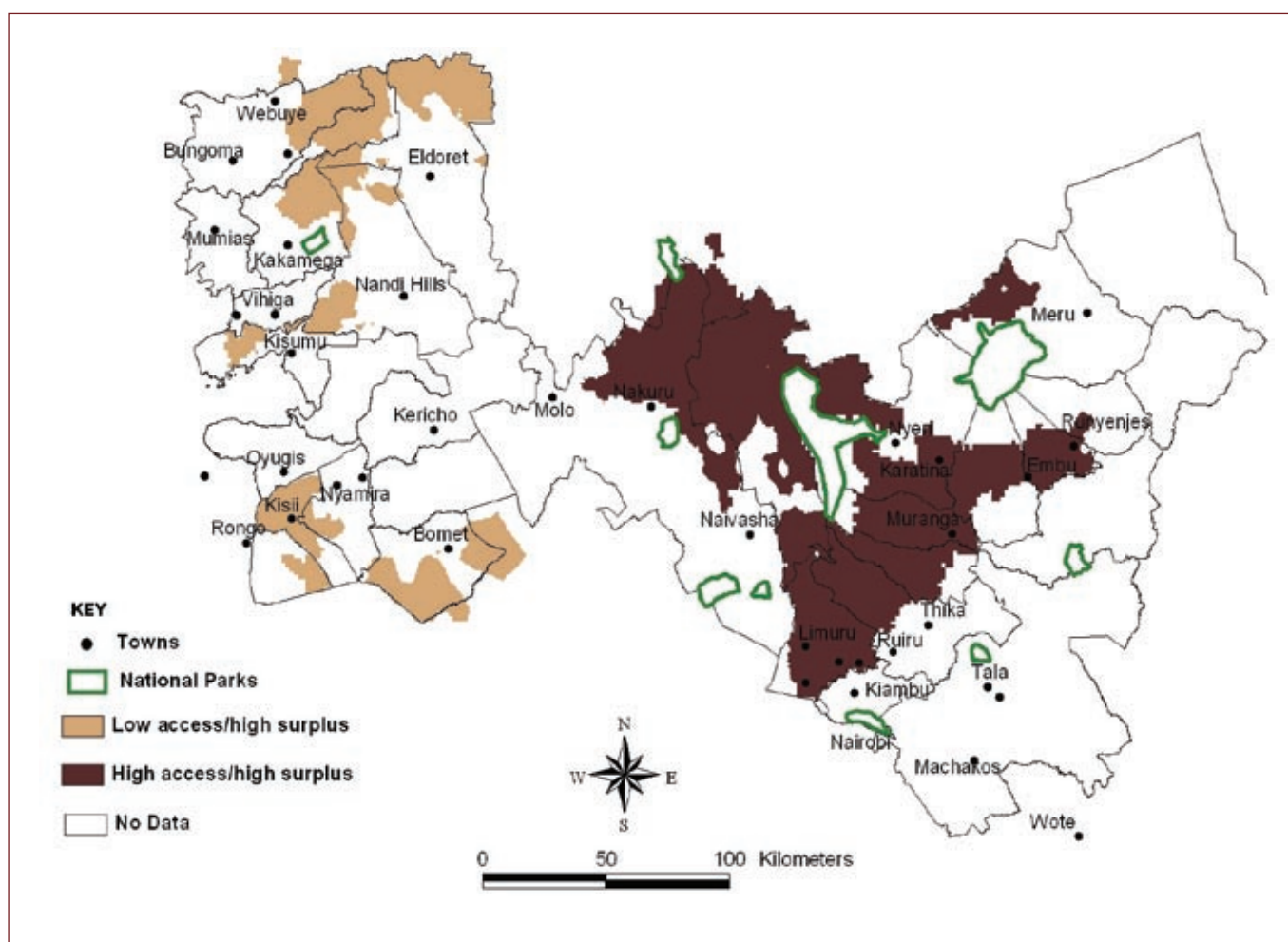
Figure 16: Combined recommendation domains for targeting of dairy co-operative development

Interpretation and discussion of the map

The dark brown areas represent regions where dairy cooperatives are most needed because they combine low market access with surplus milk production. Farmers in these areas are more likely to use collective marketing arrangements as they are unlikely to have access to alternative marketing arrangements.

The light brown areas combine high market access with high milk surplus. Farmers in these areas could still be in cooperatives but they also have other alternatives, such as private dairy companies and informal milk traders due to greater market access.

Dairy planners and development workers need to keep theses dynamics in mind when designing programs for dairy cooperative development.

Milk preservation technology

Milk is nutritious for people but also a good medium of growth for various micro-organisms. The presence of undesirable bacteria in milk may cause deterioration of flavour or physical appearance and may cause disease in people. Souring of milk, discoloration, gassiness and many other defects are caused by the presence of different types of micro-organisms.

Milk preservation is the process of preventing deterioration of milk quality by either maintaining low temperatures, as in milk coolers, or adding chemical preservatives. Lactoperoxidase (LPS) falls in the latter category and is a chemical that builds on the natural antibacterial effects in raw milk.

In Kenya milk has traditionally been preserved in cold chains. This was especially true when the Kenya Cooperative Creameries (KCC) enjoyed a monopoly in milk marketing in Kenya and ran milk coolers in different parts of the country. Following the liberalization of the dairy sector and the entry of other players in the milk marketing, most of these coolers have become dilapidated through many years of disuse. Although coolers can contribute significantly to reducing spoilage, they require high levels of technical expertise and investment to maintain, and often prove to be uneconomical, particularly where quantities of milk sold are small. During the period that milk marketing has been liberalized, chemical preservatives have also been used extensively – albeit illegally - mostly by milk traders transporting small quantities of milk to the market.

There is concern about misuse of chemicals such as hydrogen peroxide in milk preservation by some traders. Thus, there is a need for dissemination of ethically acceptable and technically appropriate milk preservation methods, such as LPS. Although use of LPS is not currently permitted in Kenya, its use has been approved by the FAO/WHO Joint Expert Committee on Food Additives (JECFA) and the Codex Alimentarius Commission. This process is natural and should not to be confused with the use of the banned and harmful chemical hydrogen peroxide. Economic viability and policy issues surrounding the use of LPS for milk preservation are discussed further in Section 3.

Why preserve milk ?

• Milk is a good medium of growth for various microbes, some of which are pathogenic.

• To prevent deterioration of quality and increase the shelf life.

• To maintain quality of milk along the value chain, particularly where the point of production is far from the point of sale.

Criteria expected to increase likelihood of adoption of milk preservation methods:

• Availability of a milk surplus: Where production exceeds demand, there will be a marketable surplus that needs to be moved elsewhere for sale. In these cases it is likely that the point of production is far from the point of sale and methods to extend shelf life are needed. Milk surplus was estimated and divisions with the highest surpluses (50% of total) were considered most likely to use milk preservation.
• Areas far from the road: Where producers are far from the road, it is likely that the milk travels further, and takes longer, to reach the point of collection and sale and, therefore, methods to extend shelf life are needed. Using the road network, distances from the road was calculated. 25% of the area, representing sites furthest from roads, was considered most likely to benefit from milk preservation.
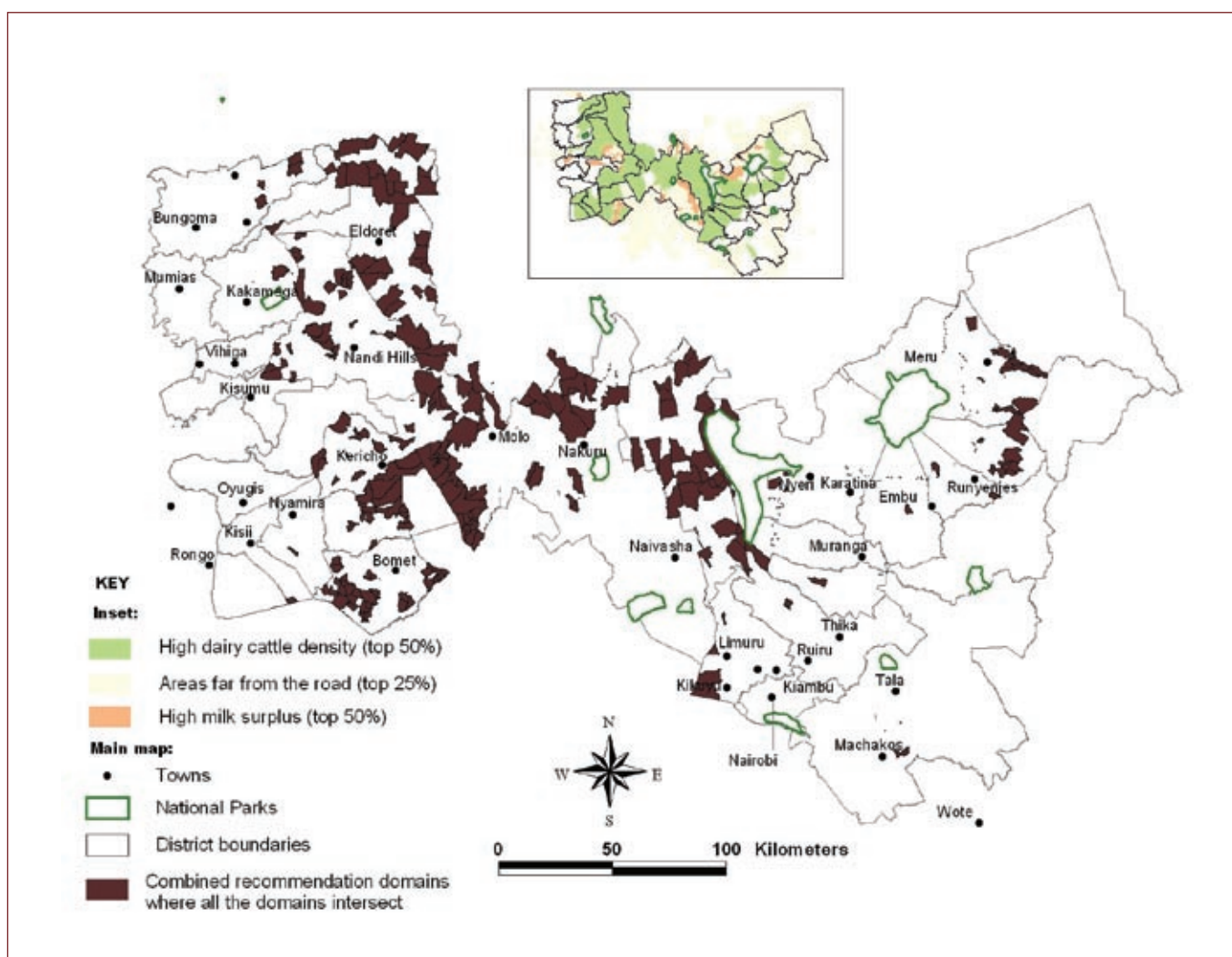
Figure 17: Combined recommendation domains for targeting milk preservation interventions

The dark areas are where all factors expected to increase probability converge and therefore, likelihood of adoption is expected to be highest. From the map above, adoption of milk preservation technologies would be highest in Nyandarua and Nakuru districts within the central highlands, Kericho and Bomet in central Rift and Eldoret and Nandi in north Rift Valley.

Training and certification of milk traders

Itinerant milk traders are a common feature of milk marketing in Kenya. They provide an important distributional network, linking producers and consumers. About 86% of Kenya's milk is sold to consumers unprocessed. Of this about half (44%) is marketed through informal mobile traders (23%), milk bars shops and kiosks (15%) and cooperatives (6%) while the other half (42%) is sold directly from farms to consumer (SDP 2004a)

The informal traders, therefore, constitute an important component of the informal milk sector in Kenya and play an important role in availing milk to low income consumers. Training and certification of informal milk traders can lead to substantial and clear improvements in milk quality. But where will the impact of training and certification of informal milk traders be likely to have the greatest impact?

To answer this question, we need to identify areas where large numbers of itinerant milk traders will be present. Milk traders will always be present where milk is produced for the market (as opposed to for subsistence). There are two clear patterns of development of informal milk trade:

1. In areas near or around large urban centres that are densely populated with consumers who cannot afford prices offered by formal outlets.

2. Informal milk trade is also active where milk surpluses are produced in remote areas where it is not economically viable for formal traders to source or sell milk. Some of these areas are only accessible to bicycles.

Why train milk traders?
- To impart knowledge on skills, processes and procedures for safe milk handling. This is important because there are public health concerns regarding milk marketed through informal channels. Training will improve quality, increase shelf life, increase consumer confidence and therefore enhances profits for the informal traders. (SDP, 2004 Training guide)
- Small scale itinerant traders are likely to be an important feature of milk trade in Kenya for a long time. Training and certification is therefore important in making these traders responsible players in a sub-sector where they are already playing a significant economic and social role.
- The informal milk sector needs to be supported and developed because it generates employment opportunities, assists poor farmers in marketing their milk and avails milk to many consumers, especially the poor. .
- Traditionally, formal channels charge higher prices because of value addition and overheads associated with formal marketing. Other secondary reasons for development of informal milk trade in these areas include delayed payments to farmers, inappropriate milk collection or delivery procedures and unwillingness of the formal sector to buy all available milk.

Criteria expected to increase likelihood of adoption of training and certification for milk traders:
- Milk surplus is calculated as the excess of milk production over consumption in an area. The extra milk that cannot be marketed through formal channels is disposed off through informal milk traders.
- Low market access: Travel time to nearest tarmac road: by bicycle of 2 hours or more: This criterion, combined with milk surplus, suggests infrastructural challenges that limit the access of milk producers in such areas by the formal market.
- Good market access: Travel time to nearest tarmac road: by bicycle of 30 minutes and less. This criterion, combined with surplus milk, allows access to densely populated urban centres whose inhabitants cannot afford milk sold through formal channels.
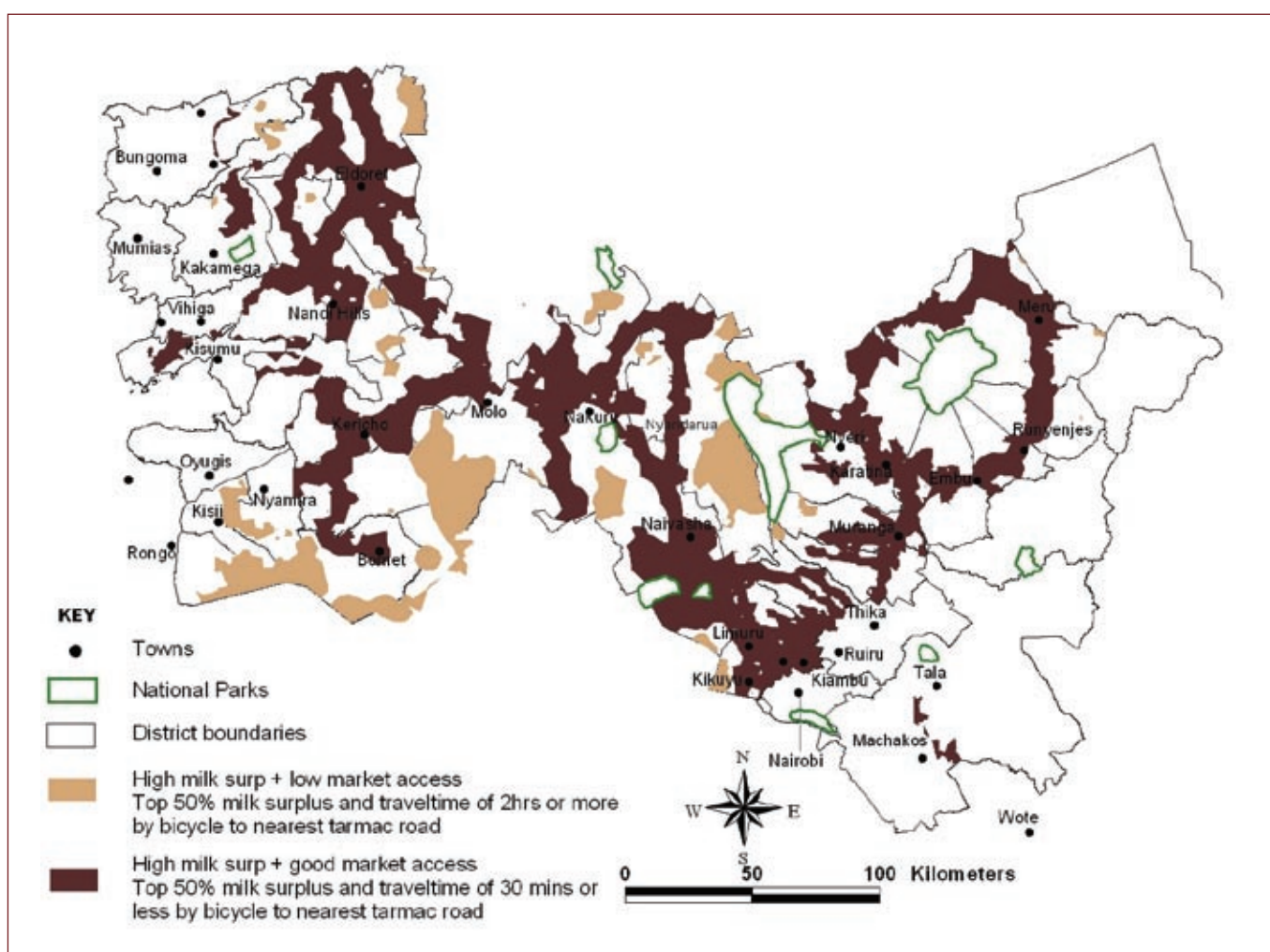
Figure 18: Combined recommendation domains for targeting training of milk traders

Interpretation and discussion of the map

Both the light brown and dark brown areas on the map represent areas where informal milk traders are likely to exist and, therefore, are prime areas for targeting interventions in their training and certification. In the dark brown areas, informal marketing develops as a result of the presence of urban populations who are unable to afford milk at prices offered by the formal channels, i.e. pasteurised and packaged milk. In the light brown areas, poor infrastructure, especially lack of roads, prevents the formal market from operating.

Section 3

Policy implications for smallholder dairy development

Introduction

The previous section dealt with identifying areas within Kenya where selected dairy interventions were most likely to be adopted so that promotion and dissemination efforts can be targeted appropriately. Technology is an important driver of dairy development in Kenya because increasing pressure on available land dictates that growth will come more from increased productivity than expansion in the scale of the dairy enterprise, such as through more land under cultivation or increasing size of herds of low productivity animals. But technology alone is not sufficient to sustain development in dairy and it has to be underpinned by appropriate and supportive policies. Indeed, the enacting and implementation of appropriate dairy policies would themselves be important drivers of the technology adoption process. This section looks at three key aspects of dairy production, presenting some results from studies conducted by the SDP and considers their policy implications. The aspects examined are:

• Cost of milk production
• Milk preservation along the production to marketing channel
• Employment generation in dairy activities

Cost of milk production

Reliable estimates of the cost of milk production are important to dairy industry stakeholders including farmers, processors, policy makers and private dairy development agencies. This information is important for decision-making related to investment in dairy development relative to other enterprises, and for the design of policies to support smallholder dairy development. Moreover, persistent complaints by farmers that producer prices do not cover cost of milk production are a further justification to identify reliable estimates of the cost of milk production. Farmers and policy makers need a dependable benchmark upon which to base their milk supply decisions; while in a market where prices have been decontrolled, quantities supplied will be based on market prices, production decisions are influenced in the long term by costs of production relative to market prices. Policy makers can use this information to determine what tariffs to levy on imported dairy products to bring parity between domestic prices and prevailing world prices.

The data

Data for the cost estimates were obtained during in-depth studies of selected representative dairy farms in Kiambu, Nakuru and Nyandarua districts between October 1997 and March 2000. A total of 21 farm households were surveyed in Kiambu and 11 each for Nakuru and Nyandarua. A longitudinal survey was done during which each farm was visited twice weekly over some 14 months to obtain daily records of milk production and sales figures, quantities and prices of inputs used in the dairy enterprise, and other relevant data (SDP 2004b; Staal et al., 2003).

No two farms are exactly the same in terms of farmer characteristics, managerial skills, technology practices and access to resources and the cost of milk production will vary according to these differences. To estimate cost of milk production, we envisaged three farm models for dairy enterprises that were deemed to be broadly representative of dairy farms in Kenya. These categories are described below:

i. Intensive production system: In this production system land holdings are smallest, stall-feeding is the main feeding practice and supplementation with purchased inputs is highest. Land is the main constraint. Kiambu district indicate division is representative of an area where the intensive dairy production system is practised in Kenya, i.e. high potential agricultural areas, with high human population density and good access to markets.

ii. Semi-intensive production system: Land is not as serious a constraint as in the intensive production system. Open grazing is common and some supplementation with purchased inputs is also done. Nakuru district is representative of areas where the semi-intensive production system is practised in Kenya.

iii. Extensive production system: In this system, which is also called pasture production system, land is not a constraint and cattle are open-grazed. Land holdings are large and there is little or no supplemental feeding with purchased inputs. Nyandarua district is representative of areas where the extensive production system is practiced in Kenya.

The results

The estimated costs of milk production from the longitudinal surveys conducted between October 1997 and December 1998 for Kiambu District and between November 1998 and March 2000 for Nakuru and Nyandarua Districts are presented in Table 3.

Cost of production was highest in the most intensive system (Kiambu) and lowest in the most extensive system (Nyandarua), reflecting the costs of the high-concentrate rations used in the more intensive systems. Profits were marginally highest in Nyandarua at KSh 4.8 per litre, followed by Kiambu with KSh 4.1 and Nakuru with KSh 3.6 per litre while sale price of milk, was highest in Kiambu and lowest in Nyandarua.

Table 3: Cost of milk production, prices, revenues and profits

Ksh	Kiambu (1998)	Nakuru (2000)	Nyandarua (2000)
Cost of production per litre	17.2	13.3	11.9
Sale price per litre	17.6	15.2	14.3
Revenue per litre*	21.3	16.9	16.7
Profit (KSh per litre)	4.1	3.6	4.8
Revenues from milk (%)	83	90	86
Revenues from animal sales (%)	17	10	14

Revenue in a dairy enterprise accrues from sales of milk and animals, and milk consumed.

It should be noted that the 'profits' described here are in fact 'above-normal profits'. This is simply because the costs of family labour have already been deducted from these returns. The results underline the important role of smallholder dairy production in sustaining rural livelihoods, smallholder dairying usually pays wages higher than those otherwise locally available. Added to this is the employment created through casual and long-term hired labour on even the smallest dairy farms, contributing to livelihoods of others within the rural community including the most resource-poor (see last section in this chapter).

Figure 19 compares individual cost components in milk production, with revenue overlaid to allow comparison between total revenue and total cost from the three types of dairy enterprise. In all the three farm models, revenue exceeded cost, showing positive returns to dairy enterprise.
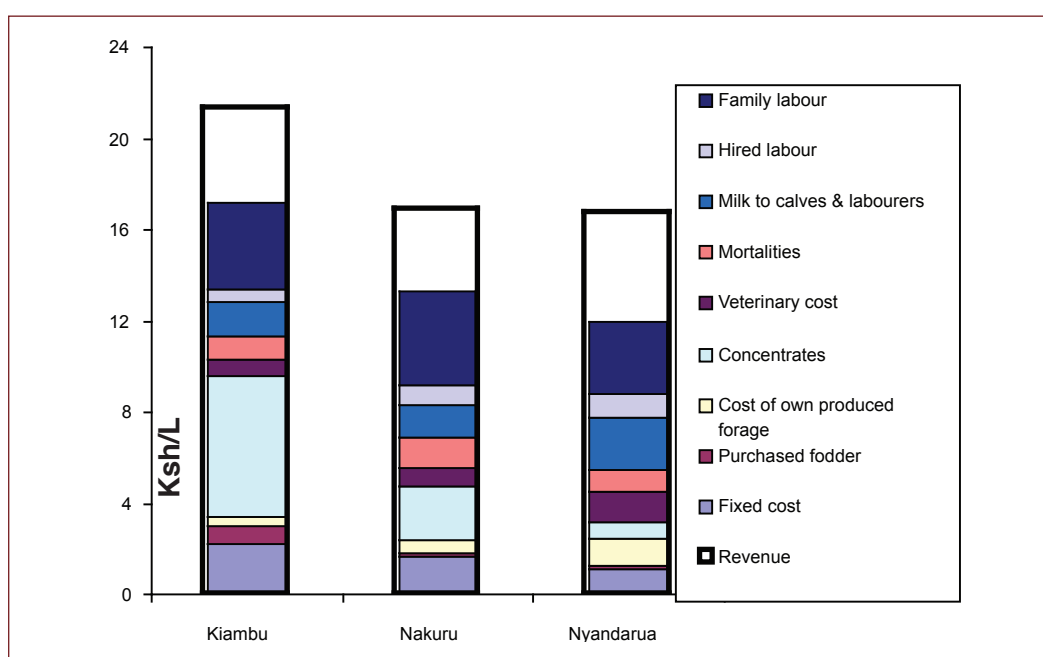
Figure 19: Comparison of cost and revenue components in three dairy production systems

However, the results presented above are for a 'normal' year, in which there is neither a drought nor more rain than average, resulting in either reduced or increased milk production. Such supply shifts can cause prices to fall or rise considerably, and thus alter a dairy farmer's financial results. In early 2002, not only did the price fall, but milk processors placed a quota on amounts delivered to their collection centres and even imposed weekly "milk holidays" when no deliveries were accepted. Simulated estimates of dairy returns for this period gave the following results of profit per litre: KSh -1.2, -1.0 and -0.8 for Kiambu, Nakuru and Nyandarua, respectively, i.e. in all three systems during this period the dairy enterprises operated at a loss. These results clearly demonstrate the vulnerability of smallholder dairy farmers in Kenya to supply shifts (see SDP 2004b).

Conclusions and policy implications

The results from the longitudinal study show clearly that in normal years, smallholder dairy producers in Kenya are able to capture useful profits. Based on the detailed daily household data, the dairy enterprise is demonstrated to provide above-normal profits, meaning that returns are higher than those available through alternative rural wage labour. This is true for a range of dairy production practices from intensive stall-feeding systems to extensive grazing systems. The understanding that farmers also capture additional but unmeasured benefits, such as from the use of manure and from the insurance and financial values of livestock assets, further strengthens their returns and competitiveness. The resilience of smallholder dairy farming as a primary provider of livelihoods in many rural areas of Kenya cannot be reasonably questioned.

Results from other studies (see Staal et al, 2000) underline the important role that road infrastructure plays, particularly in the informal market that dominates the dairy sub-sector. These have shown that farmers who are 75 kilometres or more from Nairobi can receive 22% less for their milk compared to farmers closer to the urban areas. Moreover, for each additional kilometre of poor feeder road that separates a farm from the main road, milk price is reduced by almost KSh0.50 per litre, or about 3% per kilometre. The analysis also showed that simply upgrading the poor feeder roads to good murram roads could reduce transport costs on those roads by 30%, and raise prices paid to farmers accordingly. Poor roads also significantly reduce farmer access to important support services, such as animal health and artificial insemination, which have further suffered from reduced public support since the early 1990s. Therefore, policies that target improvement of feeder roads and road infrastructure are likely to have a significant positive impact on the livelihoods of dairy farmers, particularly those in rural areas distant from major urban centres.

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The simulation analysis of the seasonal price changes seen in early 2002 demonstrated that under some supply conditions, farmers in the main milk surplus areas can be adversely affected and temporarily dairy farming can become unprofitable. Farmers using intensive production practices may be most vulnerable to these conditions. This may hint at greater long-term competitiveness of the extensive production systems if increased supply and stagnating demand lead to overall lower real farm-gate milk prices.

Reduction in demand is often due to economic decline, which contributes to lower disposable incomes and reduced purchase of milk by some Kenyan households. Efforts to raise demand through, for example, donor-funded promotional campaigns about the benefits of drinking milk, are likely to have limited success unless general economic conditions improve. Given the relatively high retail price of pasteurised milk (generally more than double the farm-gate price), efforts to reduce retail prices through more efficient processing and low-cost packing could be expected to have a greater effect in raising consumption.

Available evidence suggests that, for the foreseeable future, smallholder Kenya dairy farmers will continue to do well under a variety of production systems even though seasonal fluctuations may have temporary adverse effects on some groups. Significant farm-level profits, combined with continued milk deficits and high prices in some areas, particularly the western part of the country, suggest that public-policy support for smallholder dairy development will continue to be an effective means of improving farmers' welfare and livelihoods and stimulating rural development.

An assessment of the cost and feasibility of alternative milk preservation systems in Kenya

Many farmers in Kenya live in areas with poor roads, where electricity is lacking or cooling is uneconomical, which leads to losses of milk through waste and spoilage. Some milk market agents in such remote areas use harmful and illegal chemical agents to preserve milk. While cooling is still the preferred method of bulk raw milk preservation, an alternative method of preservation using the lactoperoxidase system (LPS) has been developed for use by small-scale farmer groups in poor milk market access regions.

Although use of LPS is not currently allowed in Kenya it is an important policy option that merits discussion and consideration. Use of LPS has been approved by both the FAO/WHO Joint Expert Committee on Food Additives (JECFA) and the Codex Alimentarius Commission which evaluates the safety of food additives and develop food standards and guidelines respectively.

The results presented here touches on:

i. The financial feasibility of use of LPS compared to milk cooling and/or no preservation at all.

ii. The potential for dairy farmers in the rural areas to increase their profitability by using LPS to preserve and sell their evening milk

iii. The institutional feasibility for use of the LPS technology in milk marketing in Kenya.

iv. The potential for LPS to replace potentially harmful chemicals used to preserve raw milk by some marketing agents.

Approach

Cost-benefit analyses of milk preservation by cooling versus using LPS were conducted to assess their economic feasibility. A case study of four milk coolers of varying sizes was conducted for information on the magnitude of costs involved. Data on costs of LPS was collected during trials with two milk collection groups in Bomet District and two private milk collection agents in Nyandarua District. Farmers in the two districts incur significant post-harvest losses in milk due to poor road infrastructure.

Results

Milk cooling
It was found that the costs of cooling range from KSh1.10 to K.Sh1.30 per litre in large-scale chilling plants (with potential capacity ≥20,000 litres/ day) to about KSh1.80 in a small-scale plant (with potential capacity = 1200 litres/day). The cost of cooling was high when utilised capacity in the cooler was low. Electricity costs, which are among the highest in Africa, account for up to 30% of the cost of cooling.

Small-scale cooling was associated with a number of problems:

i. No price premium was received for supply of chilled milk to the dairy processors even though chilling increased their operational costs significantly.

ii. The small-scale cooler was inadequately equipped (e.g. no standby generator or advanced milk quality control equipment) leading to frequent cases of milk spoilage. The spoilage of milk in the small-scale cooler accounted for 26% of the total variable costs compared to none in any of the large scale coolers.

[2] *The lactoperoxidase system of milk preservation works by activating lactoperoxidase, an enzyme naturally present in milk which has a bacteriostatic effect. It involves, first, addition and mixing of thiocyanate and, second, addition and mixing of percarbonate in good quality milk about 2 to 3 hours after milking.*

LPS method of milk preservation

Use of LPS costs between KSh1.02 and KSh1.09 per litre, which suggests that it could be economically substituted for a small-scale underutilised cooler which costs about KSh1.8 per litre. However, a few obstacles could prevent the use of LPS to preserve evening milk. These include fear by women that they could lose control of especially evening milk to their husbands as a result of heightened marketing possibilities for all milk. Moreover, preference by some farmers to sell to informal milk market agents due to low prices and delayed payment by processors may also preclude the need for LPS. It was, however, found that strategic application of LPS on morning milk to prevent spoilage when collection or delivery to the processors is delayed enhanced profitability. The private milk collection agents who, prior to these trials, routinely added hydrogen peroxide to their milk to prevent spoilage felt that LPS was better because it retained milk's natural taste and smell, and was not harmful. However, they were concerned that the cost of LPS could be higher relative to that of hydrogen peroxide. However, as has been shown, LPS cost compares favourably with chilling and could be even cheaper if procured in bulk from the international market.

Conclusions and recommendations

We conclude that cooling may not always be a solution to problems of milk spoilage and wastage due to lack of economies of scale or lack/interruption and cost of electricity. In addition, there are no premiums paid for chilled milk in the Kenyan market – thus removing a potential incentive for cooling. As a result, it could be more beneficial for some groups of farmers to use LPS. However, the prospects for use of LPS to aid dairy farmers realize higher profits through preservation and sale of especially evening milk is limited by low productivity of animals during the dry season, lack of milk market during the flush season and milk marketing problems in the formal dairy sector, such as delayed payment and low milk producer prices. Gender issues should be considered in promotion of the LPS technology since its adoption may lead to a shift in the control of benefits from milk sales from women to men – men traditionally control proceeds of formal marketing in agricultural households. Since LPS seems to be more preferable to other illegal chemicals, there is need to strive to review its legal status in Kenya. Legalization will lower its cost by making it broadly available. In addition the prohibition of LPS use in milk and milk products intended for international trade should be reviewed to foster its use and acceptability by stakeholders who participate in both local and international trade in milk and milk products.

Income and employment generation in the dairy sector

Employment and income effects at the farm-level

Poverty-reduction and employment generation are important goals in various development strategies and policies in Kenya, including the recent Economic Recovery Strategy for Wealth and Employment Creation (ERSWEC 2003) and the Strategy for Revitalization of Agriculture (SRA 2004). In these policy documents, it is recognised that dairy activities generate many employment opportunities in the course of milk production, processing and marketing.

There are an estimated 1.8 million dairy farm households in Kenya (SDP 2005), which are heavily dependent on family labour. Dairy production is an important source of self-employment, especially for rural households. A significant proportion of dairy operators also hire long-term or casual labour, which creates employment among some of the poorest segments of society, including landless households. Because most dairy activities occur within mixed crop-livestock production systems, it is not easy to attribute full-time engagement of farm households to dairy activities alone. However, it is estimated that

Table 4: Employment and income generation through dairying at the farm level

	Small-scale farms ≤2 cows	Medium-scale farms 3-6 cows	Large-scale farms >6cows	Average
Self employment (Full time jobs/ 1000L of milk produced daily)	39	17	5	23
Permanent hired labour (Full time jobs/ 1000L of milk produced daily)	60	44	43	50
Casual labour (Full time jobs/ 1000L of milk produced daily)	6	2	1	3
Total direct farm employment per 1000L milk production	105	63	49	76
Average returns to labour from dairy production (KSh/farm/year)	**38,000**	**102,000**	**482,000**	**114,000**

Source: SDP surveys, 1997-2000.
These are based on detailed random structured surveys of over 3000 households in highland Kenya.

Dairy farming generates an average annual return to labour per enterprise of between KSh 38,000 (US$ 475) and 102,000 (US$ 1,275) for small-to medium-scale farmers and KSh 482,000 (US$ 6,025) to large-scale farmers, with an average weighted annual return of KSh 114,000 (US$ 1,425) (Table 4). Compared to an average per capita GDP of approximately KSh 27,825 (US$ 347) for Kenya (World Bank, 2003), dairying provides consistently higher returns than those available through rural wage labour.

Dairying is estimated to engage more than one-third of dairy farmers on a full-time basis, which translates into some 600,000 self-employed persons. Small- and medium-scale dairy enterprises account for most (87 %) of the employment that is attributed to dairying at the farm-level, largely because of their dominance in the dairy industry in the country.

Significantly, dairy farmers also engage full-time (permanent) hired labour for dairy production activities, and also occasionally hire casual labour. Hired farm labour for dairy is estimated to represent about 585,000 workers full-time country-wide or close to a quarter of the total agricultural labour force of some 2.5 million (Table 5). In total, some 841,000 people, 34% of the total agricultural labour force, are directly employed in dairy production at the farm level.

[3]Results in this section are updated from SDP 2004c

Table 5: Direct full-time employment created through dairying at the farm level

	Small & medium scale	Large-scale	Total	Total employment in dairy as a % of the agric. labour force
Self employment	245,000	10,960	255,960	10
Long - term hired labour	454,000	93,000	547,000	22
Casual labour	35,900	2,300	38,200	2
Total (numbers)	735,000	106,000	841,000	34
% of total	**87**	**13**	**100**	

Source: SDP dairy farm data, and JICA 2003 for total agricultural labour figures

Income and employment effects at milk market level

Approximately 6 million litres of milk are traded daily in Kenya through both formal and informal small-scale and large-scale processors and traders. Beyond the farm-level, processing and marketing of milk and other dairy products offer numerous other employment and income earning opportunities for the various participants in the milk supply chain. These include transporters, mobile milk traders, milk bars and shops/kiosks, small processors, service providers such as vehicle repairs, security firms and catering outlets. Mobile milk traders do not have fixed business premises. Milk collection from producers is mainly on foot, by bicycle or public transport.

Most small-scale traders handle some 50-120 litres of raw milk daily. Traders with milk bars have fixed premises and mainly sell both un-pasteurised and fermented liquid milk. Besides family labour, paid employees are actively involved in running the milk bars.

Small processors in Kenya mostly process and sell pasteurised milk, either as wholesalers and/or retailers, with a small proportion of milk devoted to yoghurt and cheese production. They are much fewer in proportion to other cadres of milk traders.

Labour requirements in small-scale milk marketing activities include milk collection, transportation, processing and sale, creating direct and indirect employment. Direct employees are those who are occupied with milk marketing and processing on a daily basis and include the farmer, his/her family and paid labour. Indirect employees are those involved in providing services to the dairy industry, e.g. feed providers or artisans repairing farm equipment, bicycles, etc. The overall number of both direct and indirect jobs created in the marketing segment of the supply chain varied from 14 to 20 for every 1,000 litres traded on a daily basis, depending on type and scale of enterprise (Table 6). This suggests that a significant number of jobs are created considering the volume of milk that is traded via various intermediaries daily.

On average, informal milk marketing generates 18 jobs for every 1,000 litres of milk that is handled daily; this includes 15 direct job opportunities and three indirect jobs. The formal sector generates less employment per 1,000 litres of milk handled on a daily basis (total of 15) with 14 direct jobs and one indirect job. Scaling out the employment effects to cover the whole country, formal milk processing and marketing generates about 19, 000 jobs compared to the informal marketing that creates more than 41,000 employment opportunities to yield a gross total of about 60,000 jobs.

Further, these are relatively well remunerated jobs. From this study, it is estimated that formal employment in milk processing and marketing provides an average monthly wage of KSh 11, 936 ($150) while informal market agents earn an average of KSh 8,992 ($125), both much higher than the Government's minimum wage guideline of $43.

Table 6: Traded volumes, employment and wage effects in milk marketing

		Small-scale	Large-scale	Total
Aggregate Milk quantities Handled (000'L/day)†	Formal Processing & marketing	73 (1%)	1,146 (19%)	1,219 (20%)
	Informal Marketing agents	1,409 (23%)	919 (15%)	2,328 (38%)
	Direct sales from farms to consumers	2,549	0	2,549 (42)
	Total	**1,734 (46%)**	**2,041 (54%)**	**6,096 (100%)**
Rate of employment generation (Jobs /1000L handled daily) §	Formal processing & marketing	**Small-scale**	**Large-scale**	**Weighted Mean**
	Processing factory	11.6	4.5	4.8 (32%)
	Collection of raw milk	0	5.2	5.0 (22%)
	Distribution of processed dairy products	0	1.4	1.3 (8%)
	Retail of processed dairy products	3.1	3.1	3.1 (20%)
	Indirectly through supply of material & services to processors	1.2	1.2	1.2 (8%)
	Total number of jobs	15.9	15.4	15.4(100%)
	Informal Marketing	**Small-scale**	**Large-scale**	**Weighted Mean**
	Direct employment	17	11	15 (83%)
	Indirect employment	3	3	3 (17%)
	Total number of jobs	20	14	18
Scaling out the number of jobs generated country-wide ¢		**Small-scale**	**Large-scale**	**Total**
	Formal processing & marketing	1,163	17,650	18,813
	Informal marketing agents	28,177	12,863	41,041
	Total	**29,340**	**30,513**	**59,854**
Mean Wage (KSh. / Month)		**Small-scale**	**Large-scale**	**Weighted Mean**
	Formal processing & marketing	7,810	12,199	11,936
	Informal Marketing	9,550	8,137	8,992

† Numbers in brackets show the percentage market share for each category of milk marketing agent.

§ Numbers in brackets indicate the percentage contribution to the total number of jobs per 1000L of milk handled on a daily basis by each activity in the formal and also informal milk marketing sectors.

¢ Some minor differences may be observed between these figures and the products of the figures of rate of employment and quantities of milk as from this table because of the rounding off that has been done when reporting these figures.

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Annexe

Statistical model used in estimating probability of adoption of interventions

A qualitative response model was used to estimate probability of adoption of dairy interventions. Qualitative models lend themselves well to the analyses of models where the response variable is binary in nature (either 0 or 1). The response variable here is whether the technology/innovation has been adopted or not (1 if adopted, 0 otherwise), while the explanatory variables are the socio-economic and agro-climatic factors hypothesized to influence adoption or non-adoption. The logit [KRS7] and probit models fall in this family of qualitative response models. The logistic model was used in the current analysis. This model is based on the cumulative logistic probability function and specified as:

$$P_i = F(Z_i) = F(\alpha + \beta X_i) = \frac{1}{1 + e^{-(\alpha + \beta X_i)}}$$

In this notation, e represents the base of natural logarithms, which is approximately equal to 2.718.   is the probability that an individual will make a certain choice, given knowledge of . The model above can be expressed as:

$$\log \frac{P_i}{1 - P_i} = Z_i = \alpha + \beta X_i$$

This is the form used in the estimation of the logistic regression model. The dependent variable is the logarithm of the odds that a particular choice will be made and is linear to the explanatory variables X_i (Maddala, 1983 [KRS8]). The coefficients estimated from the model are transformed through a process of exponentiation to represent the marginal probabilities rather than coefficients of odds ratios. These coefficients are then used in predicting probabilities of adoption of the particular innovation.

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