Mapping and assessing high potential areas to increase milk production in Ethiopia

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Wageningen Livestock Research Report 1128

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Readers guide and summary

This report comprises an overview of 14 selected Ethiopian dairy clusters based on their current and future potential to produce milk. These clusters are assessed and compared based on: climatic conditions, biomass production, cow numbers, etc. drawn from biophysical data, regional statistics and expert judgements made by regional Ethiopian experts. General data about milk volumes, cow numbers and biomass production for all the clusters are presented in Chapter 2, in which also the evaluated 14 dairy clusters are introduced. Chapter 3 gives a brief overview of the main results, followed by a more detailed description of the individual clusters and their characteristics in Chapter 4. The strong and weak points of the dairy sector within each cluster have also been elaborated in Chapter 4.

Summary

The dairy clusters North Shewa, Adama - Arsi – Robé, and South & West Shewa-Shambu have highest scores for potential development of their dairy sectors to increase its milk production. These clusters score high on the key evaluation criteria feed and fodder production and availability, current production situation and expansion in milk volume. This means there is a strong potential to achieve growth in milk production from these clusters. A second group of four followers consists of Hawassa & Shashimene, Bahir Dar – Debre Markos, Gurage - Hosaena & Wolayita, and Gondar - Debre Tabor. These clusters also meet conditions that show poten-tial to produce extra milk. The lowest scores for future milk expansion are for the clusters East & West Hararghe, Weldiya – Dese – Kemise, and Maychew. Despite their relatively lower scores, these clusters do have unexploited opportunities for dairy development; though it will take more efforts to develop a formal dairy sector within these clusters.

Typical Ethiopian medium-scale dairy farm with cross-breds.

1 General introduction

Ethiopia faces great challenges for development of its dairy sector[1]. The large cattle population is low in milk production. Gross Domestic Product (GDP), income and consumption of milk in the country are rising, creating opportunities for an increase in the amount of milk production, milk collection and milk processing. This report is aiming at contributing to bringing more milk to the Ethiopian formal market by identifying geographical areas (called clusters) in Ethiopia with a high potential to increase milk production. The first target group of this report are future investors in the dairy sector who need more insight in the potential of Ethiopian areas to increase milk production. The second target group are policy makers who deal with tailor made solutions to support future dairy development initiatives.

The report focusses on:

- Mapping the current and potential milk production clusters in Ethiopia.
- Identifying the strengths and weaknesses of identified dairy production clusters using as main criteria: current production situation, environmental conditions for cows, feed and fodder production and availability, market access, expansion in milk volume and access to inputs and services.
- Combining data and expert opinions about the development potential of the dairy clusters.

The applied methodology for the mapping and assessing has been a stepwise approach consisting of seven steps. A detailed description of the methodology is available in Appendix 1.
Data about the Ethiopian dairy sector and expert opinions about strong and weak characteristics were the basis ingredients for the many maps, tables and graphs shown in this report.

Local cheese production.

[1] An extensive description of the Ethiopian dairy sector including challenges and opportunities can be found in the report "Investment opportunities in the Ethiopian dairy sector" (http://edepot.wur.nl/364568)

2 Introduction of dairy clusters

2.1 General description of clusters

Consultation between regional Ethiopian dairy experts and geographical data and dairy economy experts from Wageningen University & Research has resulted in the identification of fourteen dairy clusters. The clusters and their borders are shown in Figure 1.

Four clusters are located in Tigray, three are fully located in Amhara, three in Oromia, one in SNNP and another three clusters are interregional clusters crossing regional borders. The clusters were identified as areas with potential to produce more milk in the future. The woredas within each cluster are considered as having about similar conditions considering the evaluated criteria. In many cases a cluster also focusses on the same market; most of the time one or two big cities are also found within the cluster. The borders of woredas were also useful in delineating the clusters.

Some clusters around Addis Ababa are strongly focusing on the Addis Ababa market. Because of differences in the conditions described before, these clusters were not combined in just one cluster but treated as separate clusters with their own characteristics if it comes to the potential to produce more milk.

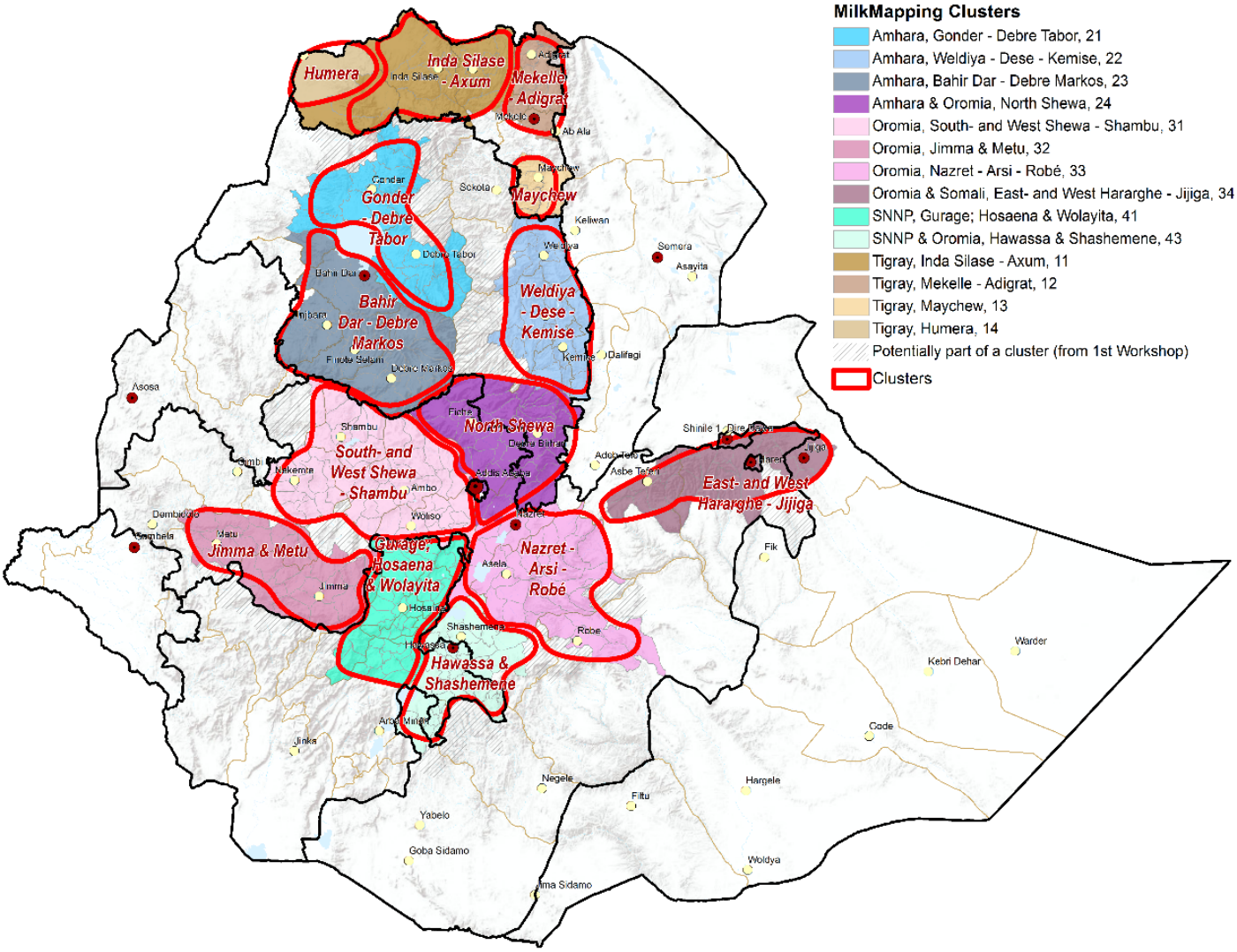

Figure 1: Defined milk production clusters and number of respective woredas.

2.2 Milk volumes and cow numbers

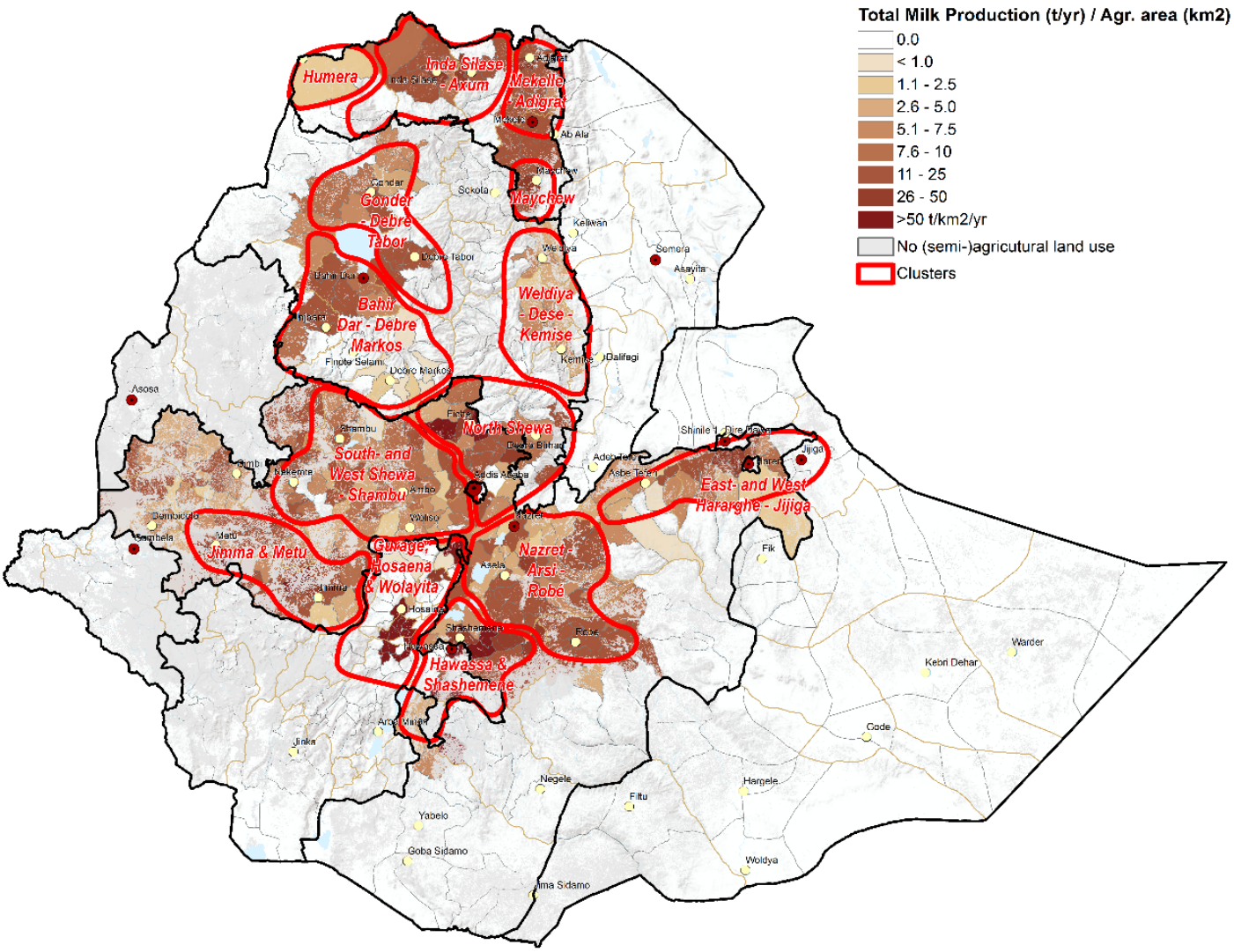

Figure 2: Total milk production per woreda within the clusters as collected by the Milk Mapping project (data 2017).

From Figure 2 and 3, it is clear that the clusters in Oromia, including cross-border clusters with Amhara and Southern Nations, Nationalities and Peoples' (SNNP) and SNNP have more dairy cows and produce currently more milk per squared km than the clusters in other regions. This is related to the proximity of the Addis Ababa market and also some other large cities within these clusters. Every cluster has one or two core areas, often around big cities like Addis Ababa, Bahir Dar, Hawassa, Haree, Dire Dawa and Hosaena; and also to a lesser extent Gondar, Injbara, Debre Tabor, Inda Silase, Mekelle and Dese.

The maps about total milk production per km^2 (Figure 2) and cattle density per km^2 (Figure 3) per woreda show similarities within clusters when it comes to these two characteristics. The data of Figure 2 are recently collected data (referring to the year 2017) and the data of Figure 3 are based on 2006 data of the Food and Agriculture Organisation (FAO). Although they are from different decades and showing different parameters (tons milk versus number of cows), both maps show quite some overlap in areas within each cluster where cows and milk are concentrated.

The data also show that, except for Humera, clusters with the largest dairy cow populations are also the clusters with largest populations of improved dairy breeds and hence the milk production per cow per year. In general: these are the clusters that are more specialized on dairy cow production in the past decades and therefore show these data.

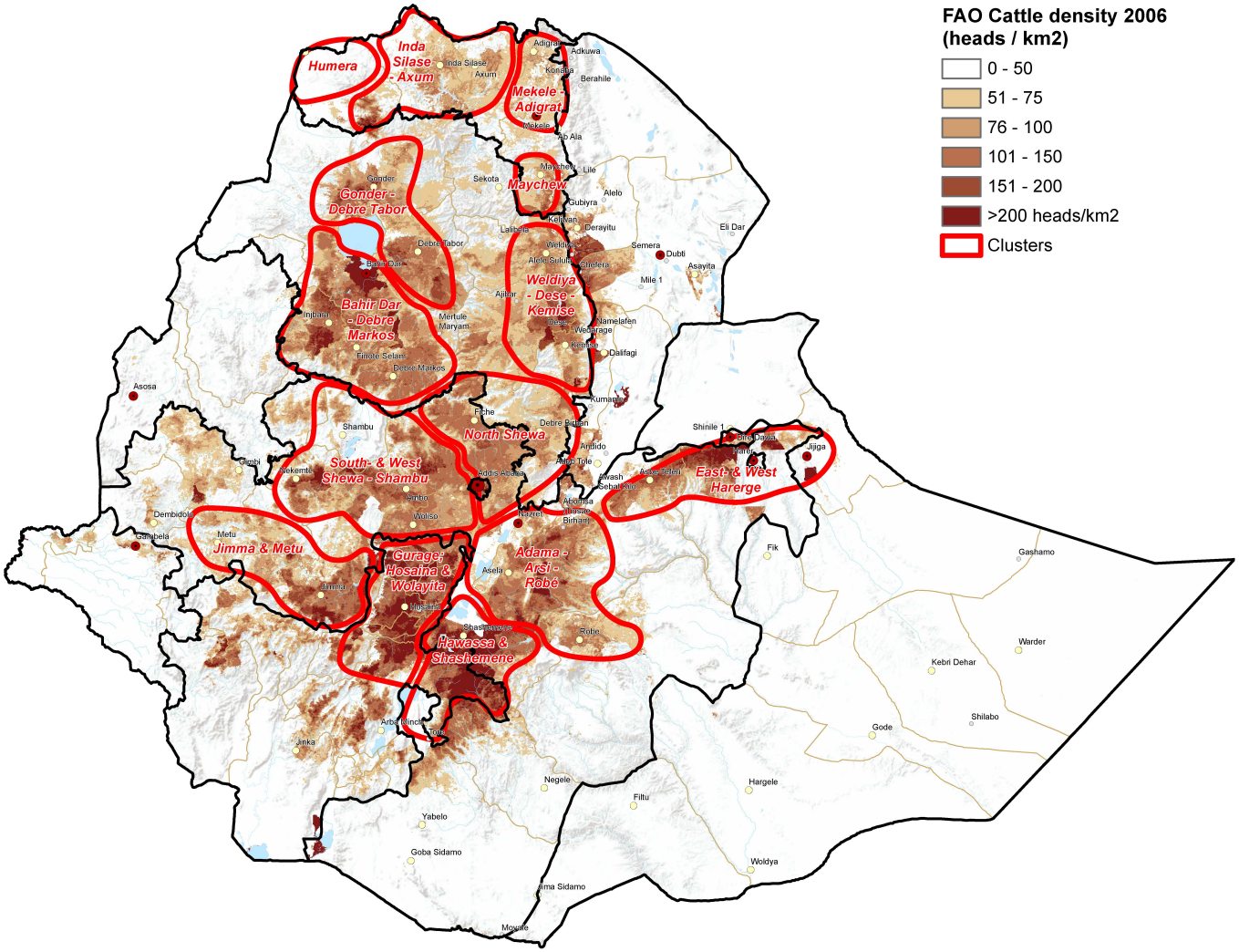

Figure 3: Food and Agriculture Organisation (FAO) Cattle density 2006 (http://www.fao.org/ag/againfo/resources/en/glw/GLW_dens.html)

The observed livestock statistics (at whatever administrative level they are available) were used to model the distribution of livestock using statistical relationships with various environmental variables. The animal densities are calculated, accounting for the amount of land suitable for livestock production, excluding them, for example, from lakes, cities and some protected areas.

2.3 Available land, land use and biomass yield

Milk production with cows requires land for feed production. This can be either grassland or cropland delivering fodder crops like maize and alfalfa or by-products from arable crops like teff, barley, oil seed plants, etc. Figure 4 and Table 1 show data about land use and land productivity to provide a better insight in the availability of fodder and feed. Figure 4 shows that crop land is the main land use in most of the selected clusters. Only in four clusters there is a fair amount of grassland (herbaceous vegetation) . This means that in other clusters by-products of arable crops will be the main fodder ingredient for dairy cows. In many clusters this will be straw from teff or other grains.

Table 1: Biomass and land productivity per cluster.

Region	Cluster Number	Cluster name	Total biomass productivity (kg/day)	Relative biomass productivity (% of total in all clusters)	Average productivity DM (kg/ha/year)
Tigray	**11**	Inda Silase - Axum	7,165,000	6.55%	11,400
	12	Mekelle - Adigrat	1,700,000	1.55%	9,700
	13	Maychew	1,084,000	0.99%	13,300
	14	Humera	1,265,000	1.16%	8,800
		Total	**11,214,000**	**10.25%**	**11,100**
Amhara	**21**	Gondar - Debre Tabor	8,577,000	7.84%	14,700
	22	Weldiya - Dese - Kemise	5,576,000	5.10%	15,000
	23	Bahir Dar - Debre Markos	13,804,000	12.62%	17,700
		Total	**27,958,000**	**25.55%**	**16,100**
Amhara & Oromia	**24**	North Shewa	9,061,000	8.28%	15,000
		Total	**9,061,000**	**8.28%**	**15,000**
Oromia	**31**	South & West Shewa - Shambu	14,905,000	13.62%	21,000
	32	Jimma & Metu	7,914,000	7.23%	29,700
	33	Adama- Arsi - Robé	10,967,000	10.02%	16,800
		Total	**33,786,000**	**30.88%**	**21,900**
Oromia & Somali	**34**	East & West Hararghe - Jijiga	7,896,000	7.22%	18,300
		Total	**7,896,000**	**7.22%**	**18,300**
SNNP	**41**	Gurage; Hosaena & Wolayita	9,975,000	9.12%	22,700
		Total	**13,542,000**	**12.38%**	**22,700**
SNNP & Oromia	**43**	Hawassa & Shashemene	5,963,000	5.45%	25,000
		Total	**5,963,000**	**5.45%**	**25,000**
Grand Total			**109,421,000**	**100.00%**	**19,400**

DM = Dry matter; Ha = Hectare

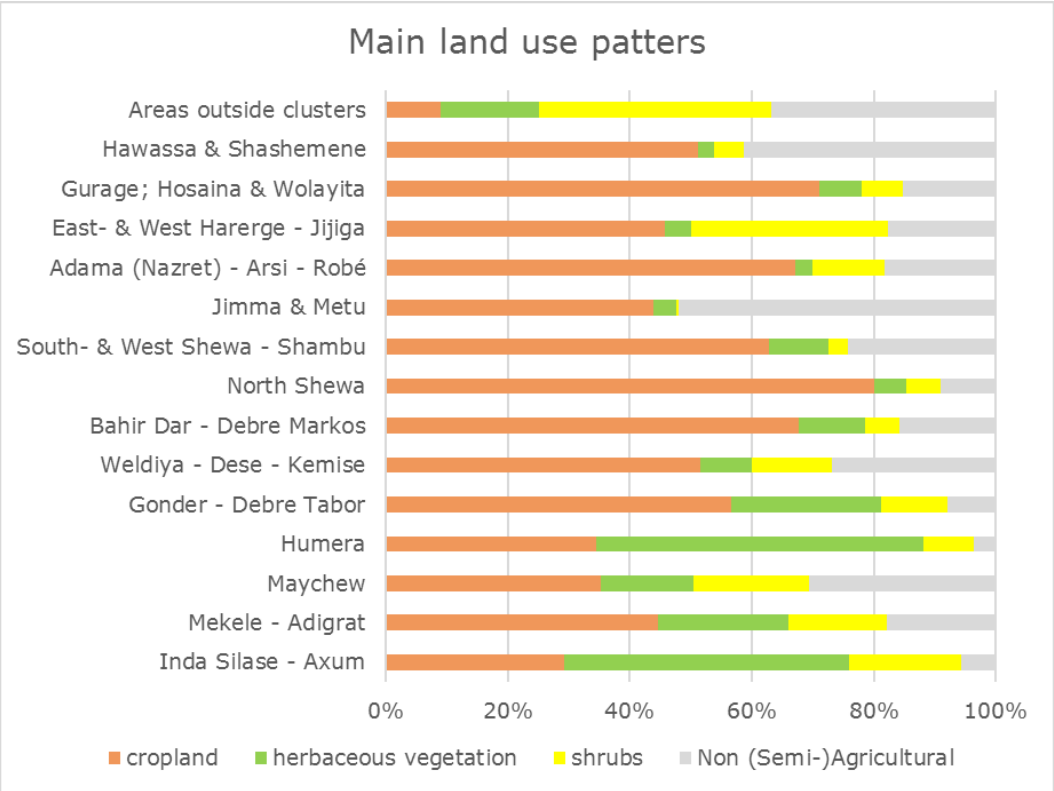

Figure 4: Land use pattern in the clusters.

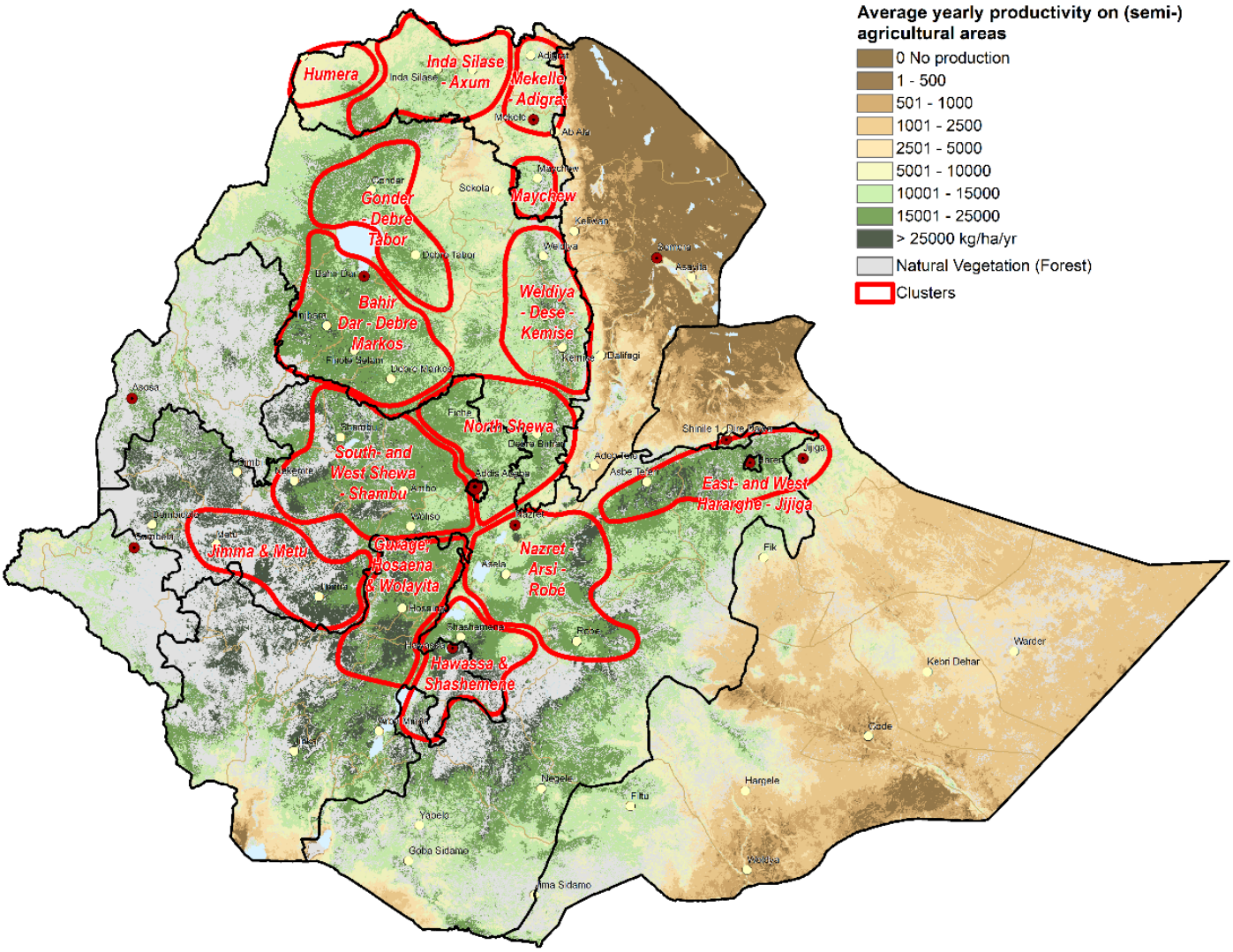

Figure 5: Actual productivity (kg dry matter production per ha per year) on (semi-)agricultural areas (total for the year 2013-2014). B (Dry Matter Productivity): based on data from: https://land.copernicus.eu/global/products/dmp.

Table 1 and Figure 5 provide information about the biomass production. Table 1 shows that biomass production per ha is the highest in the clusters Jimma & Metu, Hawassa & Shashimene, Gurage - Hosaena & Wolayita and South & West Shewa-Shambu. The main reasons for these high production per ha are rainfall and length of growing season. The clusters with the largest total biomass production are those with a higher share than 10% in total biomass production in Table 2: South & West Shewa-Shambu, Bahir Dar - Debre Markos, Adama - Arsi – Robé. Their high production is mainly caused by the large surface of these clusters.

Animal tread mill threshing teff.

3 The clusters compared: overall overview

3.1 Expert judgement score results

Table 2 summarises the overall scores of the clusters based on the evaluation by regional Ethiopian dairy experts. The evaluation was based on the twenty-four criteria which were clustered into six indicator categories in combination of weighting factors per criterion. The weighting factor was multiplied by the expert score which ranged from 1 – 5, to calculate the weighted average score per category of indicators. The complete expert scores are presented in Appendix 2.

Table 2. Summarised outcome of expert judgement on potential of dairy clusters ranked from high to low (see Appendix 2 for complete overview).

	(score scale 0 - 5)	a	b	c	d	e	f	
	Indicator	Current milk production situation	Environmental conditions for cows	Feed & fodder production and availability	Market (access)	Expansion in milk volume	Access to inputs and services	**Total overall score**
	Score weighting	20%	10%	35%	10%	15%	10%	**100%**
Region	**Name Dairy Cluster**							
Amhara & Oromia	**North Shewa**	4.5	5.0	3.8	5.0	5.0	4.4	**4.41**
Oromia	**Adama - Arsi - Robé**	4.3	4.5	4.4	4.0	4.8	4.4	**4.40**
Oromia	**South- & West Shewa - Shambu**	3.4	4.0	3.9	4.5	4.6	4.4	**4.02**
SNNP & Oromia	**Hawassa & Shashemene**	3.4	3.5	3.1	4.0	4.5	3.5	**3.51**
Amhara	**Bahir Dar - Debre Markos**	3.1	3.0	3.5	3.5	4.5	3.5	**3.50**
SNNP	**Gurage; Hosaena & Wolayita**	3.0	3.5	3.2	3.5	4.5	3.0	**3.37**
Amhara	**Gondar - Debre Tabor**	3.6	3.5	3.0	3.5	3.9	3.1	**3.36**
Tigray	**Inda Silase - Axum**	2.7	4.0	3.2	2.5	4.5	2.9	**3.26**
Tigray	**Mekelle - Adigrat**	3.0	4.0	2.1	3.5	4.3	4.2	**3.14**
Tigray	**Humera**	3.3	2.0	4.1	1.5	3.8	1.5	**3.14**
Oromia	**Jimma & Metu**	2.6	3.5	3.5	2.0	3.6	2.7	**3.09**
Tigray	**Maychew**	2.2	3.0	2.7	3.0	3.8	3.2	**2.89**
Amhara	**Weldiya - Dese - Kemise**	2.3	3.0	2.8	3.0	3.6	2.9	**2.86**
Oromia & Somali	**East- & West Hararghe**	2.3	3.0	2.6	2.5	3.9	3.0	**2.81**

This average per category is further used to benchmark clusters in spider web charts. The clusters North Shewa, Adama - Arsi – Robé, and South & West Shewa-Shambu have received the highest scores for potential development of their dairy sectors to increase its milk production (Table 2). The results of these three clusters are also shown in the spider web presentation in Figure 6, compared to the average of all clusters as benchmark. These clusters score high in all of the five main categories evaluated in Table 2. Based on the weighting, the main evaluation criterion is "Feed and fodder production and availability" (criterion c in Table 2) and all three have a high rating for this item. Meanwhile, these clusters also score very high on the indicators for expansion in milk volume, showing that there is still a strong possibility to achieve growth in milk production from the clusters.

A second group of four followers consists of Hawassa & Shashemene, Bahir Dar – Debre Markos, Gurage - Hosaena & Wolayita, and Gondar - Debre Tabor. The three lowest scores in Table 2 are assigned to the clusters East & West Harege, Weldiya – Dese – Kemise, and Maychew. Despite the relatively lower scores, these clusters have unexploited opportunities

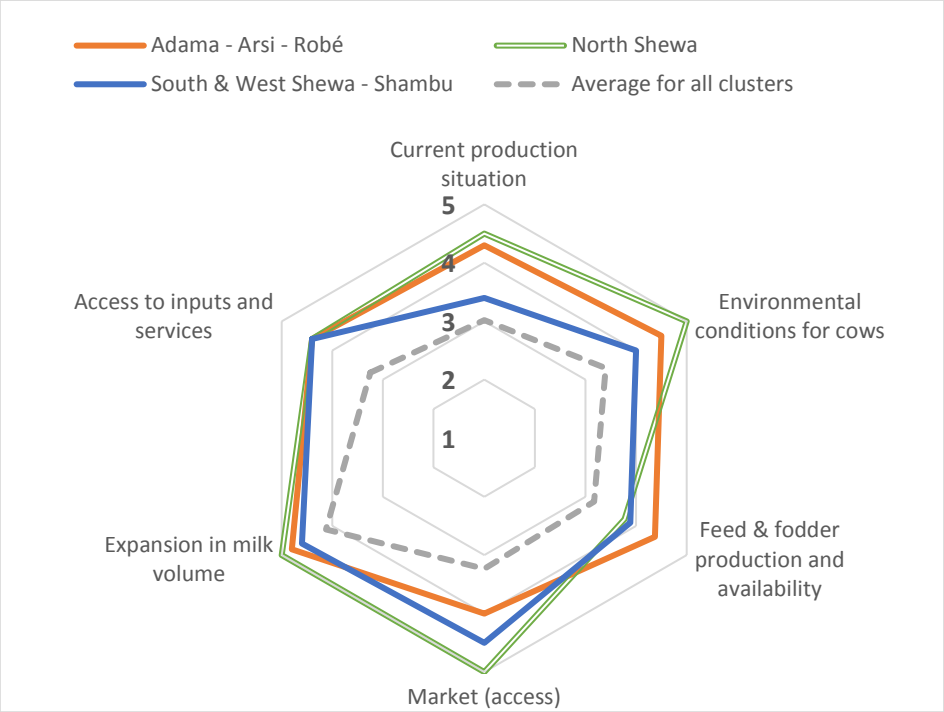

Figure 6. Results of highest ranking clusters compared to average scores of all clusters.

for dairy development which are shown in more detail in Chapter 4. The highest scoring clusters are strongly focusing on the Addis Abeba market, presently the most viable and developed dairy market in the country.

Processing companies considering to enter the Ethiopian market should be aware of the fact that the differences in development stage between clusters may mask part of the potential of clusters. Companies seeking for opportunities in the long term may choose to avoid the Addis Abeba region and develop dairy production and processing in other regions with equal milk production circumstances but less developed markets.

The weighting factors were derived during meetings with experts. See Appendix 1 for further background of these factors. These factors will depend on the goals of the assessor. The original values of the scores for the twenty four indicators – without multiplication by weighting factor - are shown in Appendix 2. The user of these result should feel free to use his or her own weighting factors for the criteria to calculate more tailor made scores.

3.2 Maps based on statistics

3.2.1 Potential based on key criteria

Figure 7 combines data based on three characteristics on potential development of the dairy sector that have much overlap with the key factors behind the main categories in Table 2. These three characteristics are:

- Total Heat stress Indicator (THI), an indicator based on the combination of temperature and humidity that shows the sensitivity of dairy cows for heat stress. Heat stress of cows results in lower milk production and bigger risk of health problems. See Appendix 3 for the calculation of THI. This indicator is strongly related to main category b (environmental conditions for cows) in Table 2.
- Dry matter productivity (DMP), an indicator for the biomass production per ha. This indicator is strongly related to main category c (feed and fodder production and availability) in Table 2.
- Percentage of agricultural land cover. This is an indicator for the percentage of land in use for agriculture. If this percentage is low, it means there will be only limited or

no facilities to enable agriculture, hence limiting the availability of local crop residues and by-products for dairy production.

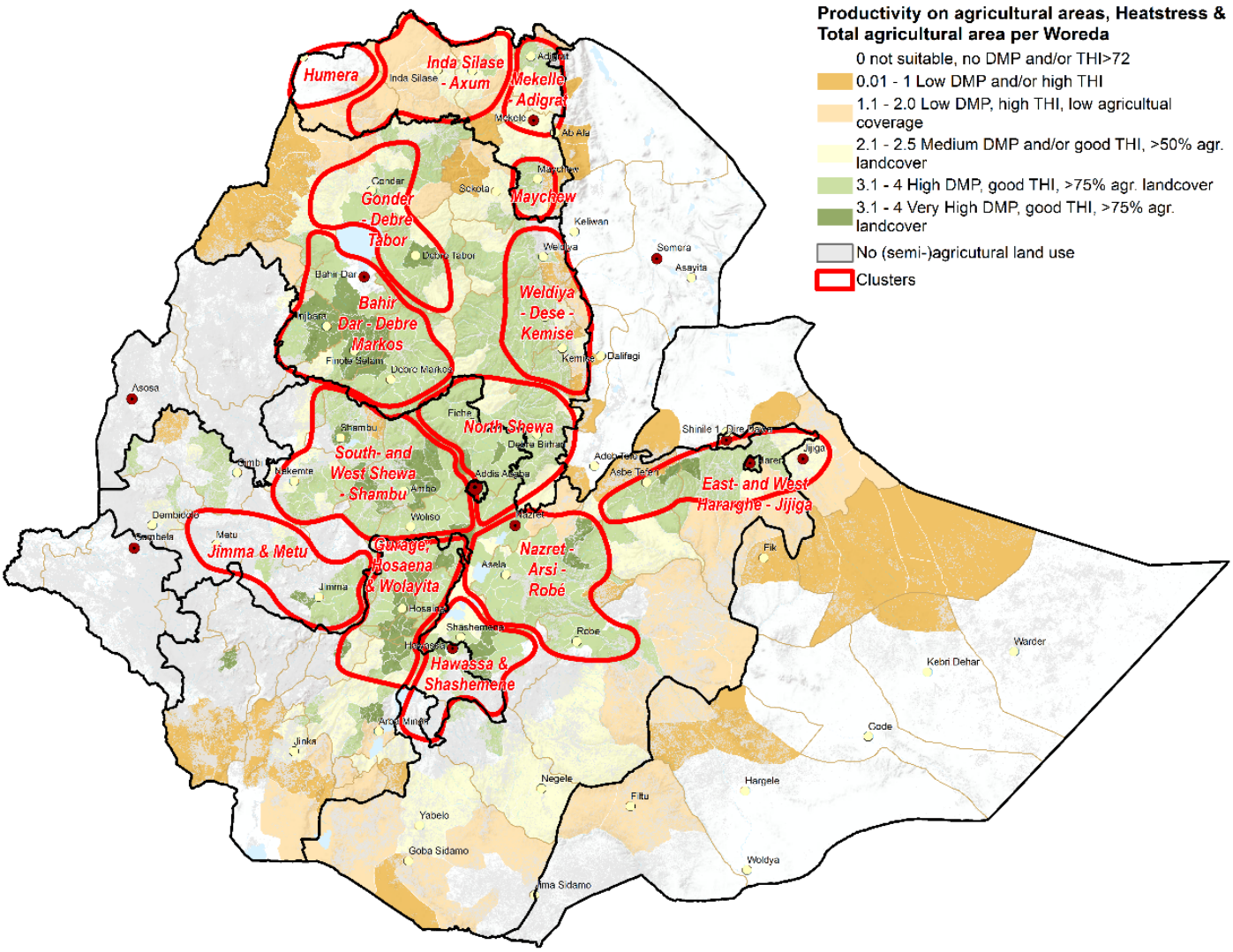

Figure 7: Classification of biophysical potential based on 1) Productivity on agricultural areas, 2) Heat stress and 3) Percentage of agricultural area per woreda. Read the accompanying text for further explanations.

Here these three criteria are quantified for every woreda, classified in classes. The results are shown in Figure 7. The legend shows which woredas score highest (dark green) for all factors and one class below the highest level (light green). The results show that the dairy clusters with highest cover of dark green area are: Bahir Dar – Debre Markos, Gurage - Hosaena & Wolayita, and South & West Shewa - Shambu. A lot of green cover as well, although ranking a little bit less in dark green, are: Adama - Arsi – Robé, North Shewa, Hawasse & Sahimene, Gondar – Debre Tabor, Maychew and Weldiya – Dese – Kemise. The potential for dairy production shown in Figure 7 is solely based on the three rational criteria listed above. The difference with priority order of clusters shown in Table 2 (general results of expert judgement) is that in Table 2 extra evaluation criteria are incorporated in the rating, including present milk volumes and cows, market access, entrepreneurship and access to inputs and services. Adding these items results in a relatively higher rank of the clusters North Shewa, Adama - Arsi – Robé, and Hawasse & Sahimene.

In Table 2 the cluster Humera is scored high in feed and fodder production and availability by the experts. Figure 7 shows that cluster Humera is a cluster with little potential. This is caused by the low share of agricultural area and the poor climate conditions for dairy cows due to the more severe heat conditions. In Table 2 the most limiting factors mentioned are expressed in low scores for respectively "b" (environmental conditions for cows) and "f" (access to inputs and services).

Based on Figure 7 also the conditions in the clusters Inda Silase - Axum, and Mekelle-Adigrat are quite hard for expansion of milk production. The experts are more positive about this potential of these two clusters, mainly based on relative high scores for expansion potential and environmental conditions for cows.

From figure 3, we see that in most cases cattle density per km^2 inside the selected clusters is higher than outside these clusters. Figure 7 shows a combination of the underlying factors that have caused this image of Figure 3: productivity on agricultural areas, percentage of agricultural area and heat stress (details described in Appendix 3). Both figures (3 and 7) clearly carve out the central part of the country, showing a wide belt from the north between Gondar and Mekelle, running southwards to Hawassa and Robe being a very high potential area for milk production. This is because of the suitable temperatures and humidity which limit heat stress in cows, more available arable land, and a relatively higher crop productivity which could translate to higher fodder yields or increased availability of by-products for feeding cows.

Interestingly, Figure 2 shows there is a relatively high milk production per km^2 from Humera and parts of Inda Silase - Axum, which are mapped as less favourable in terms of weather conditions (heat stress) and also have a low biomass production. The high milk density is likely due to a large number of local cows which are highly adapted to the local weather conditions, consuming poor quality forage, but also producing less milk per cow per year as elaborated in chapter 4. The areas west of Dessie running from Lalibela through Mertule Maryam and also the area North of Gambela, from Dembi Dolo through Jimma seem to have a good potential for dairy, however they did not fall into any of the selected clusters. Looking at Figure 11, we can justify that these areas are further away from big cities which means that their dairy development could be limited due to difficulties in accessing inputs and access to the market.

Communal grazing grounds (North Shewa).

3.2.2 Additional criteria

Absence of tsetse flies

In Figure 8 the cattle density already shown in Figure 3 is combined with the prevalence of Tsetse flies. The presence of Tsetse flies has a very negative impact on cow health. The map shows that in the western part of the country, mainly in the triangle between Gambela, Ginka and Jimma, there are many spots where tsetse flies are predominant and have resulted in low

cattle densities and hence low milk productivity. The tsetse predominance zones also explain the exclusion of some areas from the selected clusters: cows are absent in the woredas where the fly is present. This presence is a blocking factor for dairy development. Some of the selected dairy clusters have presence of tsetse flies on their edges. This is the case in the three most southern clusters and on the northern and western borders of South & West Shewa - Shambu. These parts are not appropriate for dairy production.

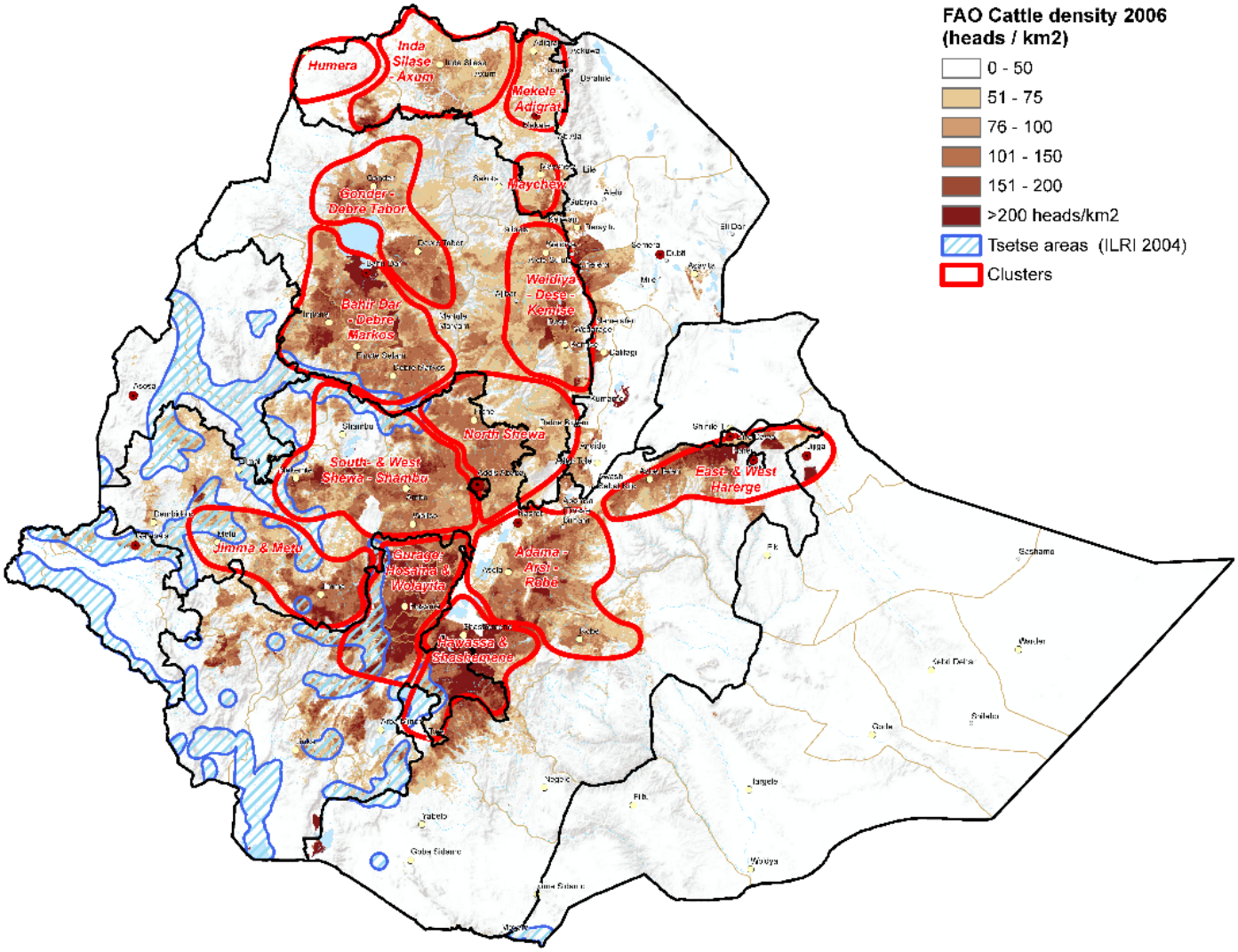

Figure 8: FAO Cattle density 2006, with overlay from TseTse-areas (based on data from ILRI, 2004).

Land cover: arable crops and grass

Based on the availability of fodder crops and grass products, the conditions for efficient dairy production with cattle are the best in clusters with crops and herbaceous vegetation. Figure 9 and Figure 10 show the land cover in the selected clusters. Cropland is the dominant land use in all the clusters. The class "cropland" also includes cropland-grassland-mix. This mixed type of land use is difficult to grab from satellite images, especially if the parcels are small. Only in some clusters in Tigray and Amhara large shares of the land within the clusters is covered with herbaceous vegetation (grassland).

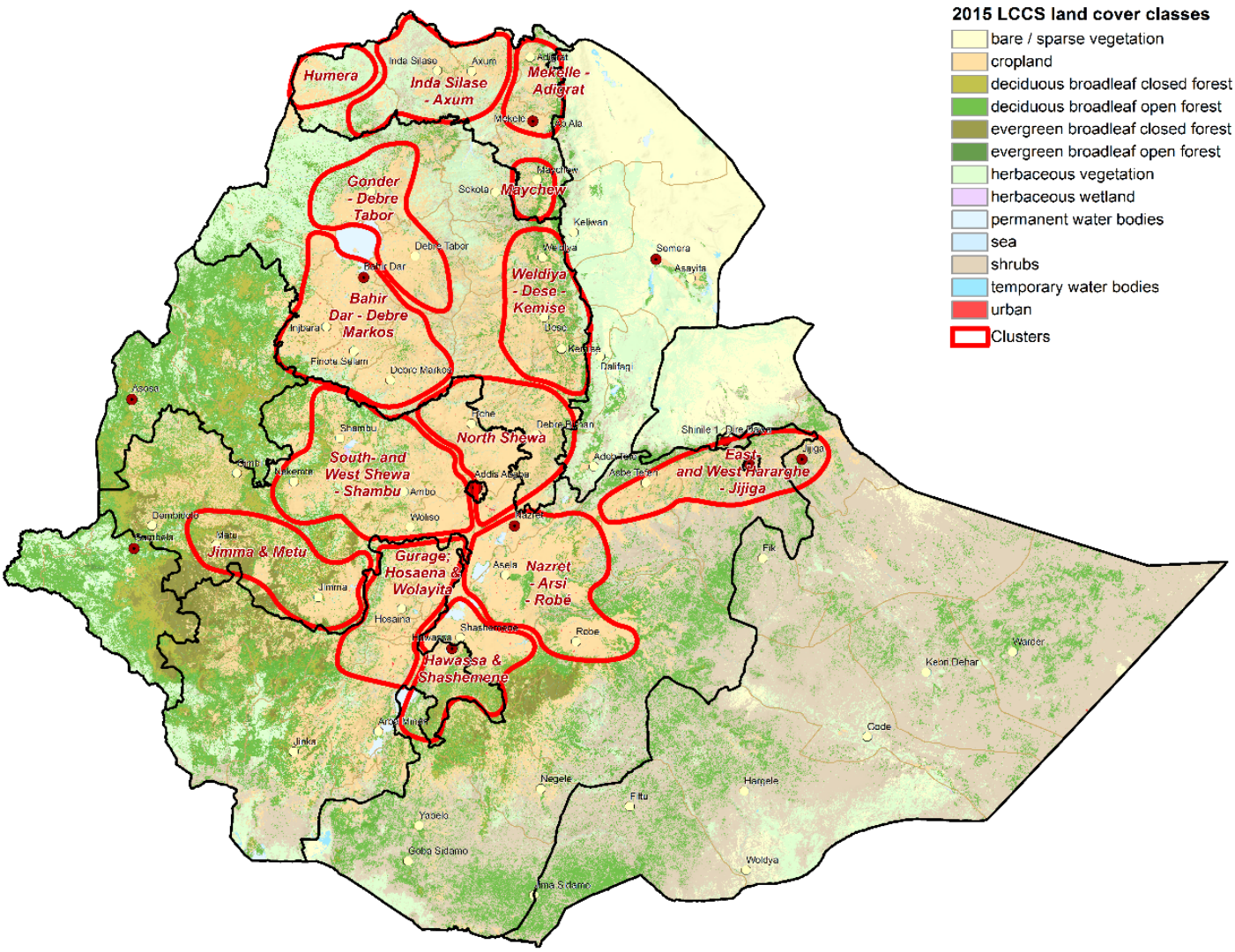

Figure 9: Land cover (Proba-V, 2015).

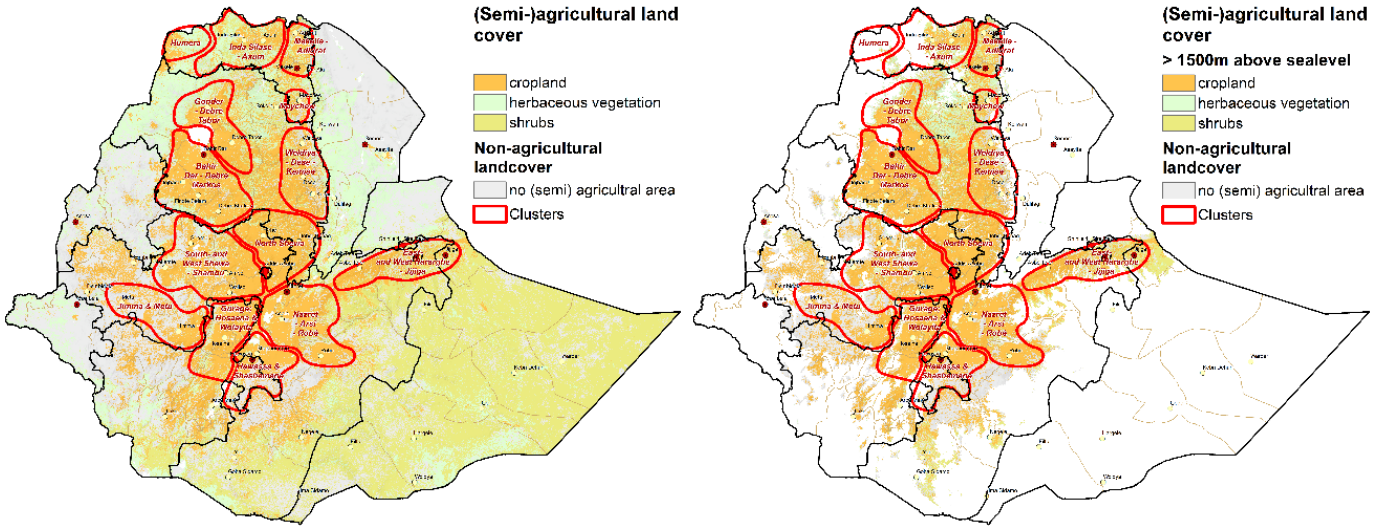

Figure 10: Main Agricultural Land cover (left) and Main Agricultural Land cover for areas >1500m (right) (Clustered from Proba-V, 2015, Figure 9).

Proximity to cities

Figure 11 gives information about the proximity of cities. This is an indicator of the proximity of markets for dairy products. The map shows that the yellow 50 km distance zones around cities cover our dairy clusters quite well. All areas within a cluster are in 100 km distance zones from cities. Figure 12 shows the same kind of information but is referring to the more concrete travel time to cities with over 50,000 inhabitants.

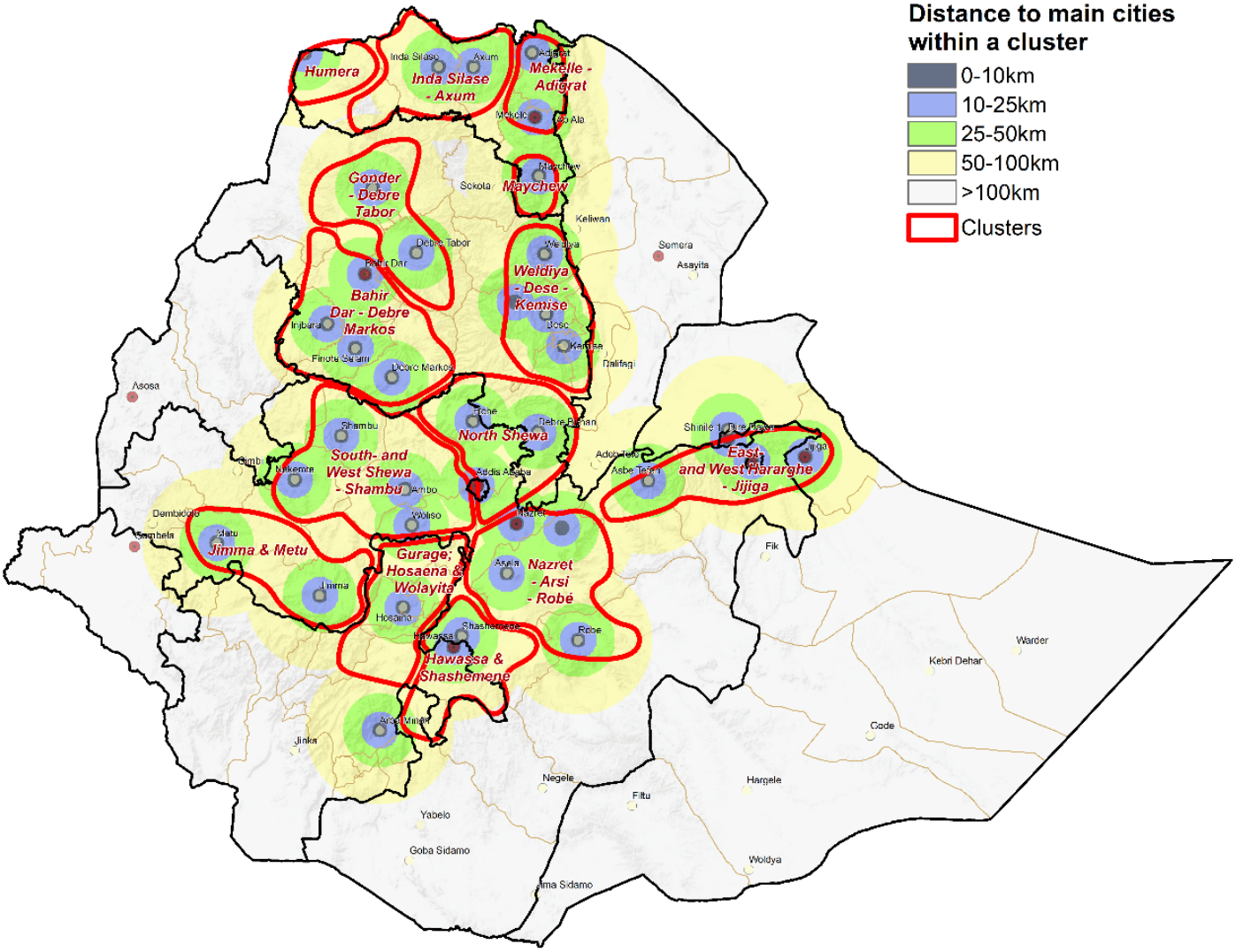

Figure 11: Distances to main cities within the cluster.

Peri urban produced fresh milk reaching Addis Ababa market.

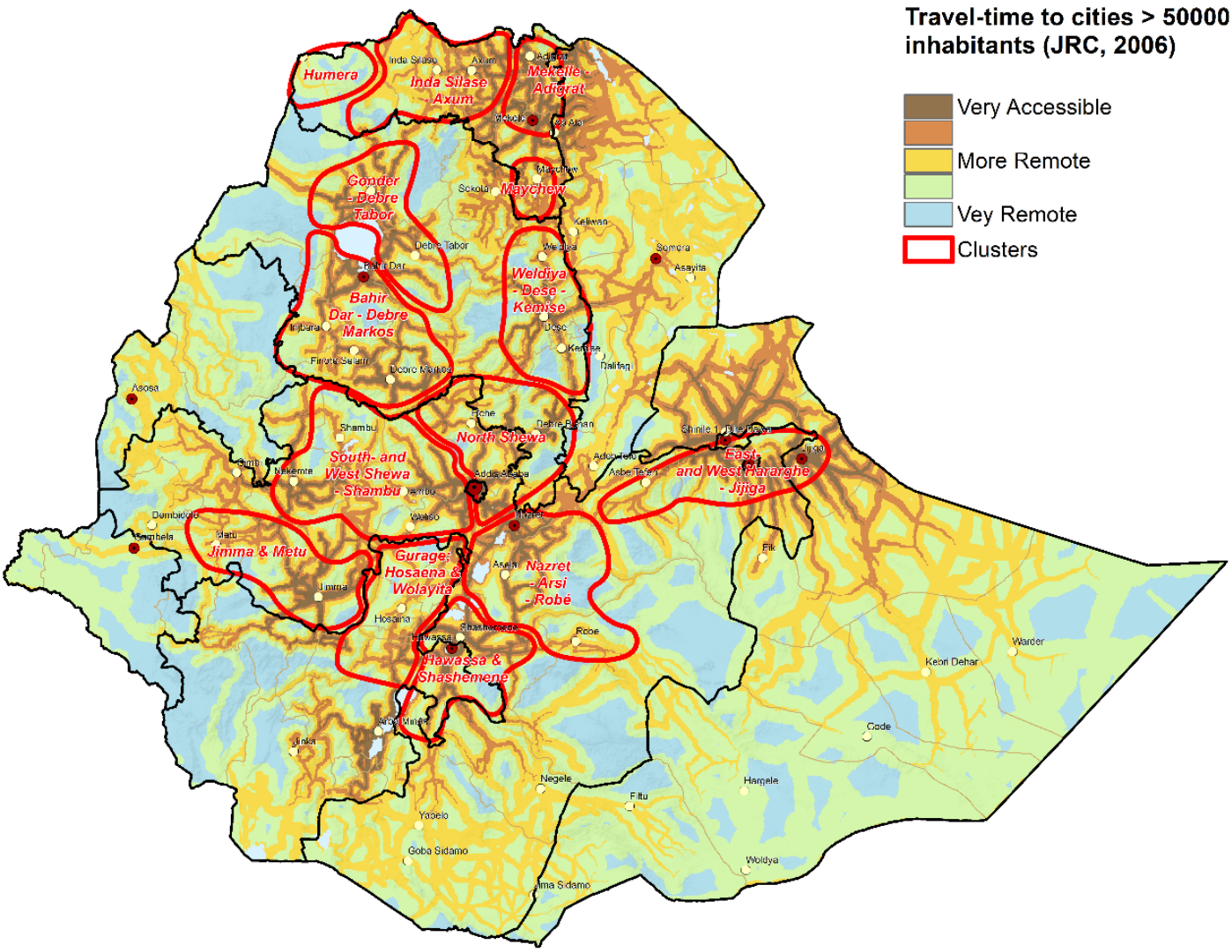

Figure 12: Travel time to cities with 50,000 or more inhabitants.

Milk collection at road side collection point.

4 The clusters in detail

This chapter further describes all fourteen dairy clusters, bringing out the factors driving dairy production at present and in future. To facilitate understanding, these clusters have been grouped by region (Tigray, Amhara, Oromia, and Bahir Dar). For each region, the clusters have been benchmarked using spider charts and tables. The spider charts show a mean score of six groups of indicators (shown in Table 2 and described in the Appendix 1 Table A1) scored on a scale of 1 – 5, with 5 showing the best potential and 1 the least potential. For each cluster, there is a table that describes the predominant dairy production systems and another table to highlight the strong and weak points of the cluster in regard to current and future potential for dairy production.

4.1 Clusters Tigray

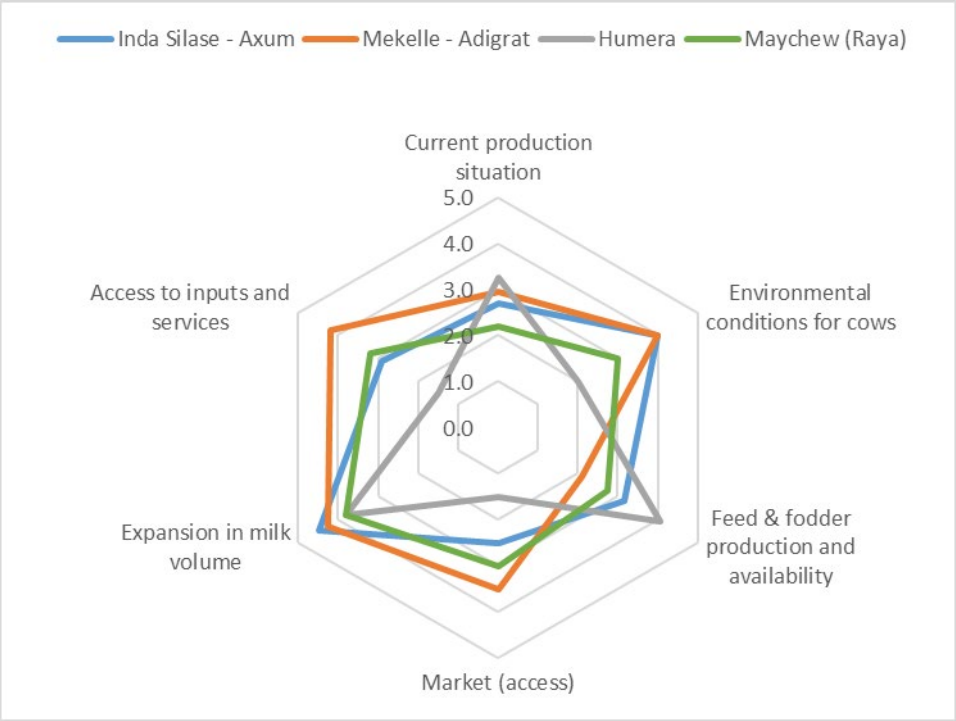

Figure 13: Benchmarking the clusters in Tigray.

In Tigray, based on the web chart (Figure 13), all the clusters have a good potential to expand in milk volume. The cluster Mekelle-Adigrat shows the highest potential in the region in terms of access to input services and market access. This is mainly driven by the high demand for milk and dairy products in Mekelle, which is the largest city of the region. Meanwhile Inda Silase-Axum has the highest potential for expansion in milk volume, and both Inda Silase-Axum and Mekelle-Adigrat clusters have the most favourable environmental conditions for cows in the region. Interestingly, Mekelle-Adigrat scores lowest in feed and fodder productivity and availability, which is an important criteria for future growth. This contributes to the slightly lower overall score (see Table 2) of 63 in Mekelle-Adigrat compared to 65 in Inda Silase-Axum. This shows that future growth in the Mekelle-Adigrat cluster will depend on purchased feed from outside the cluster. Figure 13 shows that the Humera cluster does not have favourable environmental conditions for cows. It also has poor access to inputs and services and a poor market for milk and dairy products. Despite these challenges, Humera still has a high current production level and a good capacity to expand milk production using feed and fodder from within the cluster.

4.1.1 Humera

Farming System		Explanation
Agro-pastoral	60 %	traditional lowland crop-livestock farming
Mixed crop-livestock	25 %	traditional midland/lowland mixed farming
Urban / Peri-urban	15 %	emerging smallholders specialized in dairy
Specialized commercial	< 1 %	intensive dairy farming
Cattle		**Milk production**
Herd size: > 5 cows	± 50 %	
Indigenous	99.8 %	
Begait		6.2 litres/day for 195 days
Arado		2.7 litres/day for 140 days
Improved breeds	0.2 %	11.92 litres/day for 280 days

The high temperature, often exceeding 25ºC is probably the main reason for a low percentage of improved breeds in the Humera cluster. Fodder in this cluster is mainly hay and crop residues. The availability and use of improved forage and industrial by-products) is limited.

Developments in dairy sector

Formal milk (channelled through a milk processor) constitutes less than 1% of total milk. Traditional milk processing is common through cooperatives. Humera has one major processing plant with a capacity of 6,000 litres per day which is expected to go into operation before the end of 2018. There are two feed processing plants in Humera (1 Union and 1 Private). There is also one large agro-industry park in Humera/Baeker which is currently under construction by the government. There are five dairy cooperatives and one union active in Humera which produce mostly butter. People in some parts of this cluster strongly believe that milk should not be sold, but should be consumed at the household or shared freely with friends and relatives. However, in the town of Humera where milk sales is more common, the milk price ranges from 11-12 ETB per litre during the non-fasting period to 8-10 ETB per litre in the fasting period. More so, in this cluster, ghee is more commonly supplied to the market than milk, and at an average price of ETB 200/kg. In the urban and peri-urban areas they also process about 10% of the milk into sour milk "Ergo".

Strong points	Weak points
• Availability of cropland, mostly rain-fed, as a potential feed source for straw from teff, stover of sorghum and maize, cotton seed, and sesame by-products • Availability of rangeland as a potential feed source for grass or hay • The cluster has a ranch which is established to preserve the local productive Begait dairy cows • Availability of drinking and irrigation water from the Tekeze river (the cluster is near to the river) • Presence of more than 100,000 in Begait dairy cows which are an adaptable local breed of relatively high productivity compared to other local cows • Presence of the Welkait Sugar Factory (almost operational) as a potential feed source for molasses and sugar cane by-products • Agro-industry park in Humera/Baeker (under construction) which is established by the government	• Heat stress is likely in almost 90% of the cluster • Animal health risks: lumpy skin disease and foot and mouth disease • Low number of improved dairy cattle and little use of artificial insemination • Little practice of irrigation • Little market development for raw milk, ergo and the local soft cheese "Ayib". Milk is mainly used for home consumption and by herdsmen • Low availability of improved feed (concentrate feed and industrial by-products) and forage seeds • No large milk processing plant in operation • Low availability protein-rich by-products like oil seed cakes and brewers grain • Little government attention given to the dairy sector, more focus on sesame

Most needed investment areas: processing capacity, animal health, irrigation and fodder improvement.

4.1.2. Inda Silase – Axum

Farming System		Explanation
Agro-pastoral	10 %	traditional lowland crop-livestock farming
Mixed crop-livestock	60 %	traditional highland mixed farming
Urban / Peri-urban	28.5 %	emerging smallholders specialized in dairy
Specialized commercial	1.5 %	intensive dairy farming
Cattle		
Herd size: > 5 cows	± 25 %	
Indigenous	98.5 %	
Begait		
Arado		
Improved breeds	1.5 %	

Inda Silase - Axum is one of the clusters with the largest farms. Most of the fodder used is hay and crop residues and a few farmers also use improved forage and industrial by-products.

Developments in dairy sector

Formal milk accounts for less than 1% of the total milk. There is a recent plan to establish one processing plant of 10,000 litres capacity in Inda-Selasie city by AGP II project (Agricultural Growth Program funded by the World Bank).

This project is also working on strengthening milk collection through cooperatives and unions in the cluster. There are feed processing factories in Adwa and Tahitay-Maychew, both owned by the union. This cluster has 23 cooperatives and one union, the main product from milk is butter and a small amount of yoghurt is also processed and sold in urban and peri-urban areas. The milk price is about 20 ETB per litre in non-fasting periods, and 10-12 ETB per litre during fasting periods.

Strong	Weak
• Availability of cultivated land, mostly rain fed, as potential feed source for straw and by products of teff, wheat, sorghum, maize and sesame • Availability of rangelands with potential for grazing and fodder production • Presence of Tekeze river (in three woredas of the cluster) as a potential source for livestock drinking water and for irrigation • Large herd of potentially high milk producing cows (300,000 Begait and some 15,000 crossbred dairy cows) • Near to Welkait Sugar Factory as a potential source for molasses and other sugar cane by-products • Near to the large agro-industry park in Humera/Baeker which is being established by the government • Temperature Humidity Index (THI) favourable for improved dairy breeds • Tourist market for specialized dairy products	• Almost 15% of the dairy cluster is potentially heat stress area. • Some animal health risks like lumpy skin disease and foot and mouth disease • Practices on fodder improvement and irrigation are not developed and not common • No current local market for milk products like yoghurt, cottage cheese and cream. Only raw milk and butter are commonly sold. • Limited use of improved feed (concentrate feed and agro-industrial by-products) • Low availability protein-rich oil seed cakes, brewers grain • Low availability of forage seeds • No chilling facility and milk processing plant currently functional in the cluster

Most needed investment areas: dairy value chain development, fodder improvement, processing capacity.

4.1.3 Mekelle-Adigrat

Farming system		Explanation
Agro-pastoral	2 %	traditional lowland crop-livestock farming
Mixed crop-livestock	56 %	traditional highland and midland mixed farming
Urban / Peri-urban	40 %	emerging smallholders specialized in dairy
Specialized commercial	2 %	intensive dairy farming
Cattle		**Milk production**
Herd size: > 5 cows	± 10 %	
Indigenous	95.3 %	
Begait		6.32 litres/day for 195 days
Arado		2.57 litres/day for 140 days
Improved breeds	4.7 %	12.94 litres/day for 280 days

The Mekelle-Adigrat cluster does not have pastoralists. Fodder mainly comes from hay and crop residues, and local brewery by-products. Farmers in this cluster have some level of utilization of improved forage and industrial by-products and practice the cut and carry system.

Developments in dairy sector

Approximately 5% -10% of the milk production goes to the formal chain. There is one processing plant of 6,000 litres capacity owned by a federation and two small private cottage processing plants in Mekelle, each of them having an average capacity 3,000 litres/day. There are 3 feed processing factories owned by 3 unions in Mekelle, Samre and Adigrat. Meanwhile, there are 43 dairy cooperatives and one dairy union in the cluster. The main dairy products are: yoghurt, butter, buttermilk, and some (about 10%) cheese in urban and peri-urban areas. Milk price in the non-fasting period 25 ETB per litre; in fasting period 12-15 ETB per litre according to the type of fasting.

Strong	Weak
• Almost 85% of the cluster is medium (not hot and cold) climatic condition and suitable for dairy production • 15% of the cluster is cold climate, and more appropriate for improved breeds • Good practice of forage development and utilization activities because there is broad practice of irrigation throughout the cluster • Availability of small parcels of grazing land as a potential for grass or hay • Potential in crossbred dairy cows (around 25,000) together with good practice of feeding the dairy cows could result in for huge milk volumes • Near to Raya Beer Factory as a potential for brewery by-products • Proximity to the city and good market opportunity for fresh milk and dairy products like yoghurt, butter, buttermilk, cheese and cream • Relatively high level of utilization of improved feeds (concentrate feed and other industrial by-products available) • Presence of active cooperatives and unions which are responsible for milk collection and processing	• Have less area of land under cultivation as compared to Humera and Axum-Inda Selasie dairy clusters • Animal health risk of lumpy skin disease, foot and mouth disease, calf mortality, blindness and lameness • Low availability of forage seeds • Lack of land for dairy (small land holdings) • Water scarcity

Most needed investment areas: commercial fodder production, water harvesting, animal health.

4.1.4 Maychew (Raya)

Farming System		Explanation
Agro-pastoral	5 %	traditional lowland crop-livestock farming
Mixed crop-livestock	74.5 %	traditional highland mixed farming
Urban / Peri-urban	20 %	emerging smallholders specialized in dairy
Specialized commercial	0.5 %	intensive dairy farming
Cattle		
Herd size: > 5 cows	± 20 %	
Indigenous	98 %	Raya, Arado, Bergait
Improved breeds	2 %	

Fodder is principally hay from natural pastures and crop residues (teff straw, green maize stover). The use of improved forage and industrial by-products is limited. Although the use of concentrates is limited, more concentrate is used here than in the other three clusters of Tigray.

Developments in dairy sector

There is one processing plant of 6,000 litres capacity under construction in the cluster which is owned by Bokra Union in Maychew. The cluster has two feed processing factories owned by the union in Maychew and Mokoni. The project AGP II (Agricultural Growth Program funded by the World Bank) is working on strengthening milk collection cooperatives and the union in the cluster. The cluster has 12 cooperatives and one union. Common dairy products include soar milk/ergo, butter and buttermilk. Milk price ranges from 20 ETB per litre during the non-fasting period to 10-12 ETB per litre in the fasting period.

Strong	Weak
• Suitable for dairy production from crossbred dairy cows (almost 75% of the dairy cluster is cold and medium -not hot and cold- climatic condition) • The practice of forage development and utilization is better than in the other clusters in Tigray and irrigation is practiced within this cluster • Availability of grazing (pasture) lands as a potential for fodder production • Potential in Raya breed cows and crossbred dairy cows (around 6,000) together which - if well managed and fed - could generate huge milk volumes • Potential availability of brewery by-products (from Raya Beer Factory) • Good market opportunity for milk and dairy products like yoghurt, butter and buttermilk • Market-oriented producers which use higher levels of concentrate • Well organized milk collection and processing by cooperatives and union • Three chilling facilities and one milk processing plant (owned by Bokra union which is currently being established) • High local demand for milk, more tradition on consumption of milk and dairy products, less seasonality in milk demand • The cactus plant is very common and the fruits can be used as a feed source	• Heat stress can potentially occur in almost 25% of the dairy cluster • Have less area of land under cultivation compared to Humera dairy cluster • Animal health risk of lumpy skin disease, foot and mouth disease • Low availability of forage seeds in the market • Low utilization of sorghum stover, which is available but is often burned on the farms

Most needed investment areas: genetic improvement, feed and fodder management – including ration formulation and valorisation of local feed material.

4.2 Clusters Amhara

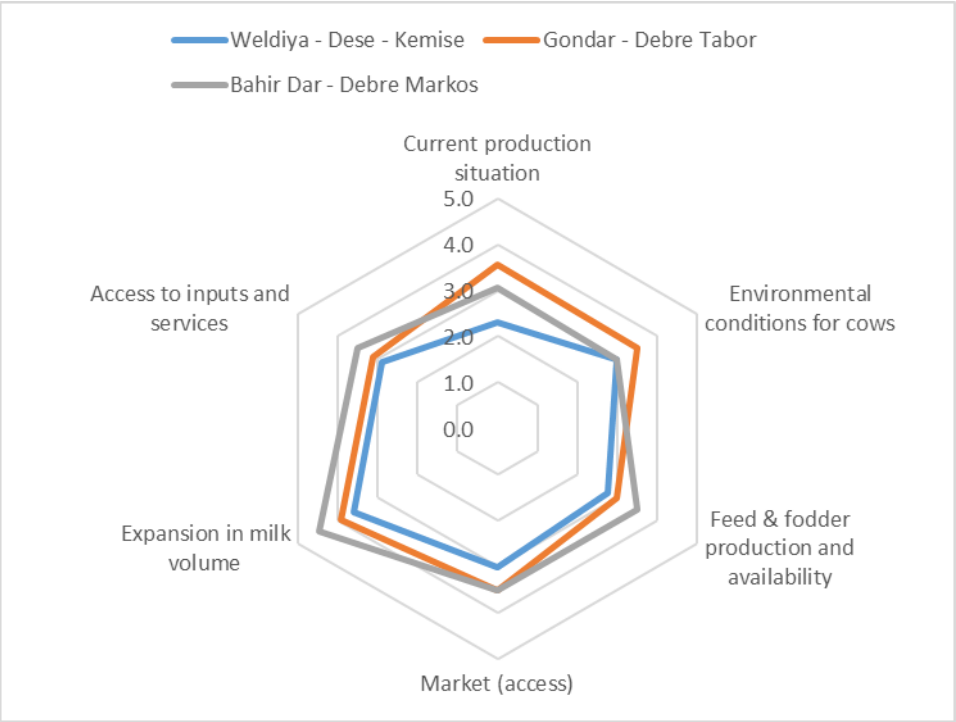

Figure 14: Benchmarking the clusters from Amhara.

Based on the web chart, the clusters in Amhara show visible differences in potential for milk production. Weldiya – Dese – Kemise cluster shows a distinctively lower potential compared to the other two clusters in the region. Meanwhile, Bahir Dar – Debre Markos cluster has slightly higher overall potential than Gondar – Debre Tabor cluster because of a better access to inputs including feed and fodder and a better possibility to expand its milk volume driven by proximity to Bahir Dar, the regional capital. Gondar – Debre Tabor cluster however has a higher current milk production and more suitable environmental conditions for dairy cows compared to the Bahir Dar – Debre Markos cluster.

4.2.1 Gondar – Debre Tabor

Farming system		Explanation
Mixed crop-livestock	± 80 %	semi intensive highland mixed farming
Urban / Peri-urban	± 20 %	emerging smallholders specialized in dairy
Specialized commercial	< 1 %	intensive dairy farming
Cattle		
Herd size: > 5 cows	± 4 %	
Indigenous	95 %	
Improved breeds	5 %	

Developments in dairy sector

The cluster is characterised by a high farm gate price for milk of (18 – 20 ETB per litre), driven by high demand.

The cluster has one liquid nitrogen plant in Gondar and two feed processing plants owned by the cooperative union. Agro-industrial by-products are available from one sesame processing plant in Gondar and from many small-scale oil

processors and grain mills (wheat, barley, peas).

Strong	Weak
• High population of dairy cows • Conducive climate for improved dairy breeds • Availability of crop residues • Existing cooperatives working on milk (e.g. Jantakel) • Experience in growing fodder (hay), backyard fodder production • Focus on livestock since topography is not suitable for crops • Small and large scale irrigation schemes available in the area • Good market due to urbanization and high demand for milk in Gondar • Support from the World Bank to displaced people due to large scale irrigation; they are encouraged and supported to carry out dairy farming	• Dominance of local breeds and traditional management systems • Focus on dual-purpose animals for milk and draft • Poor genetic material due to poor (mainly public) AI services by incompetent technicians and shortage of liquid nitrogen • Small farm sizes, average about 0.75 ha per farm • Milk transportation is an issue due to long distances and poor transportation facilities • Shortage of concentrates (limited brewers grain) • No vocational centres and no research centres for dairy • Poor access to credit, especially for dairy investments • High proportion of milk wasted because of poor value chain development and poor knowledge of processing

Most needed investment areas

- Heifer production farms.
- Feed processing.
- Commercial dairy farms.

4.2.2 Weldiya - Dese – Kemise

Farming system		Explanation
Mixed crop-livestock	± 75 %	
Urban / Peri-urban	± 25 %	
Specialized commercial	< 1 %	
Farm size	0.5 ha	
Cattle		
Herd size: > 5 cows	± 5 %	
Indigenous	95 %	
Improved breeds	5 %	

Developments in dairy sector

The average annual farm gate milk price in the cluster is 16 ETB per litre. The cluster has one liquid nitrogen plant in Dese, one brewery and one oil processing factory.

Maize stover waiting to be collected.

Strong	Weak
• More market oriented zero-grazing systems common • Little fluctuations in milk demand (majority Muslims) • Focus on dairy cattle; less use of animals for draft • Focus on livestock since topography is not suitable for crops • High market demand (high number of factory workers) • Some small-scale irrigation; relatively good source of feed • Available crop residues from cereals and pulses • Good potential for fodder – large forest coverage (grass grown under forest) • Forage cultivation is common practice (with land allocation to forage and also mixed cropping with forage at border of farms)	• Dominance of local dairy breeds and traditional management systems • Low animal productivity • Poor extension and AI services, no private services • Shortage of heifers, especially of improved breeds • No formal processing plant • Feed (concentrate and roughage) shortage especially in the dry season • Mid-high altitude, not as convenient as Gondar (less rain and poor rain distribution) • High proportion of milk wasted because of poor value chain development and poor knowledge of processing

Most needed investment areas

- Feed processing plants.
- Breeding (genetic improvement).
- Commercial dairy farms.

4.2.3 Bahir Dar - Debre Markos

Farming system		Explanation
Mixed crop-livestock	85 %	
Urban / Peri-urban	14.5 %	
Specialized commercial	0.5 %	
Farm size	1 ha	
Cattle		
Herd size: > 5 cows	± 6 %	
Indigenous	94 %	
Improved breeds	6 %	

The average farm size is about 1 ha per farm. The average farm gate price was 15 ETB per litre.

Developments in dairy sector

The cluster has one liquid nitrogen plant in Bahir Dar, one semen collection centre (bull dam farm) in Bahir Dar, one genetic improvement ranch in Chagene and two feed processing plants owned by the cooperative unions. Agro-industrial by-products are available from many small-scale processors. About 2% of milk is processed in formally by two processing plants with capacity 60,000 and 30,000 litres per day.

Strong	Weak
• Flat topography and easy transportation of milk • Weather condition is convenient for forage production • Farmers are more exposed to the cultivation of improved forage (Napier, Sesbania) • Good access to crop residues • Government plans to develop an agro-industrial park (Bure) • Increasing demand for milk and dairy products due to urbanization • Many dairy cooperatives are operating in the cluster • Farmers are business oriented and willing to accept new technology and can afford low-cost technology • Availability of by-products from many agro-processing (wheat, oil etc.) plants • New investors are building factories in the cluster, it is expected to improve the dairy potential • Small and large scale irrigation and watershed development • Feed supplementation is becoming more common in the cluster	• Dominance of low yield local breeds • Common use of communal grazing with less effective land use • Less attention is paid to dairy by the public sector as compared to crop production • Poor access and quality of AI and vet services - shortage of improved heifers • Weak cooperatives • High proportion of milk waste because of poor value chain development and poor knowledge of processing • Limited supply of improved forage seeds • Lack of specialization in dairy because of more focus in crops • High prevalence of animal diseases specially in low gorge areas of the Abay river catchment

Most needed investment areas

- Market development (communication).
- AI services.
- Dairy processing plant.

4.3 Clusters Oromia

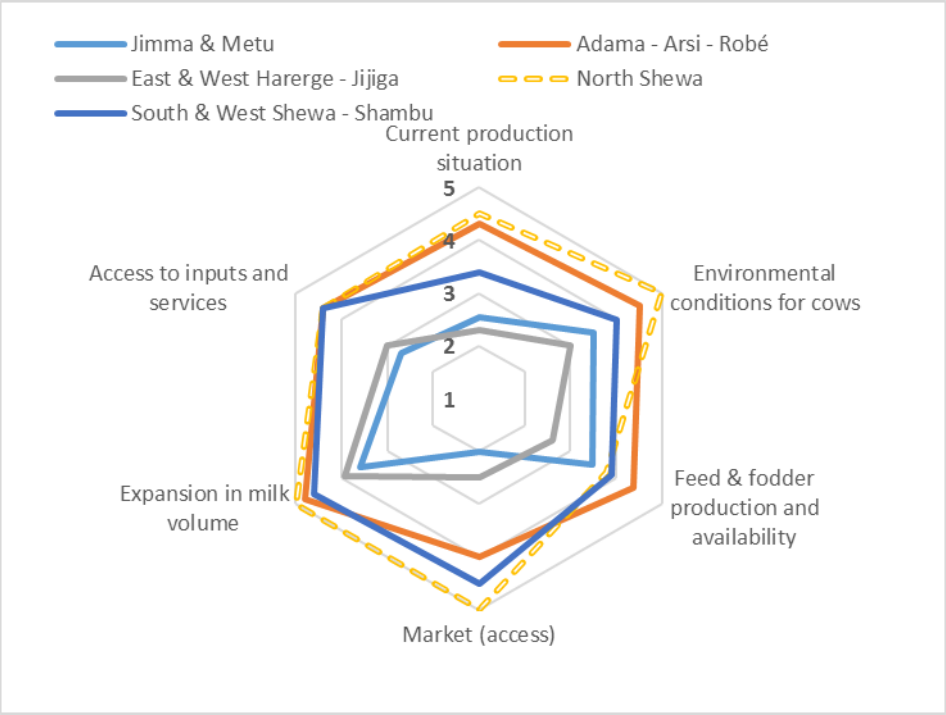

Figure 15: Benchmarking the clusters from Oromia.

The proximity of Addis Ababa gives the Oromia clusters a number of advantages for the dairy sector. The government has selected areas in Oromia as milk commodity priority areas and it has been a core implementation area for several projects. The density of technicians, extension

workers, AI specialists and other players supporting the dairy industry is high around this area which equally has more infrastructure. The region has:

a) Liquid nitrogen plants in Fiche, Nekant, Herna, Assela, Kaliti, Jima and Shashemane.
b) One national semen collection centre (bull dam farm) - in Addis.
c) Three genetic improvement ranches: in Boran, Arsi and Horo.
d) About 37 cooling facilities: milk chilling tanks in Oromia with a capacity of 2000 litres each.

4.3.1 North Shewa

Farming system		Explanation
Mixed crop-livestock	± 80 %	semi intensive highland mixed farming
Urban / Peri-urban	± 20 %	(emerging smallholders specialized in dairy
Specialized commercial	0.5 %	intensive dairy farming
Cattle		
Indigenous	81 %	
Improved breeds	19 %	cross and pure exotic breeds

Developments in dairy sector

This cluster has the highest proportion of cross and pure exotic breeds. The cluster has one liquid nitrogen plant in Fiche, holds huge potentials for dairy development and is exposed to several interventions due to its proximity to Addis. This makes production more market oriented and more commercial dairy farms are established. Formal milk chain constitutes about 53% of total milk and most of the rest is used for producing traditional products that are sold informally.

Milk price ranges from ETB 12-18 depending on the season and cultural and religious events.

Strong	Weak
• High potential and high demand • Relatively high proportion of cross breeds or improved breeds (large population) with productivity up to 30 litres per cow per day • Different project interventions in the cluster • Improved pasture and forage development (hay making, silage making (only for commercial farms, straw treatment, tree Lucerne, mixed pasture etc.) • Conducive weather conditions for dairy • Availability of both private and public veterinary and insemination services • Good infrastructure development – easy transportation of raw milk to processing plants in Addis • Big commercial/specialized farms exist in the area • Many processors and dairy cooperative unions in the area • Existing liquid nitrogen plant in the areas • Existing feed processing plants, crop residues and agro-industrial by-products	• Seasonally in demand and high fluctuation in milk prices • High cost of feed and poor quality of feed due to feed adulteration and poor enforcement of quality regulations • Small farm sizes • Lack market oriented dairy extension and vet services • Milk collection by processors is limited to main road side • Processing plants operating below their capacity leading to high operational costs per unit • Lack of technical capacity to maintain processing equipment (no national experts), lack of spare parts, poor quality of imported spare parts • Poor linkage between producers and processors, many middlemen involved • Shortage of improved seeds, less attention paid to fodder production

Most needed investment areas: dairy value chain development, fodder improvement, service provision hubs.

4.3.2 South-west and West Shewa-Shambu

Farming system		Explanation
Mixed crop-livestock	95 %	traditional highland mixed farming
Urban / Peri-urban	5 %	emerging smallholders specialized in dairy
Specialized commercial	0 %	
Cattle		
Indigenous	81 %	
Improved breeds	19 %	cross and pure exotic breeds

Developments in dairy sector

The cluster has one liquid nitrogen plant in Nekemte, one semen collection centre (bull dam farm) in Nekemte and one genetic improvement ranch in Horo.

Strong	Weak
• Availability of agro industrial by-products (flour mills, brewery and sugar industry) • Availability of crop residues • Presence of universities and research institutes working on dairy issues • Suitable agro-ecology and temperature • Availability of land for fodder production and practicing of free grazing • Availability of dairy cooperative unions • Presence of vet clinics and vet laboratories	• Poor infrastructure and market • Limited quantity and poor quality of feed and forage • Poor dairy extension systems • More focus on food crop production, less on dairy • Lack of highly productive forage seeds • Disease prevalence especially *Trypanosomiasis* (in west) • No milk processing centres

Most needed investment areas: feed and fodder management, processing capacity.

4.3.3 Jimma-Metu

Farming system		Explanation
Mixed crop-livestock	98 %	traditional midland/highland mixed farming
Urban / Peri-urban	2 %	emerging smallholders specialized in dairy
Specialized commercial	0 %	
Cattle		
Indigenous	%	
Improved breeds	%	

Developments in dairy sector

Agriculture is predominantly coffee and some rice production. There is one liquid nitrogen plant in the cluster located in Jimma. The cluster has a high consumption per capita from the high proportion of Muslims who consume milk throughout the year.

Strong	Weak
• High demand for milk. Milk is often used as a coffee creamer and this creates huge potential for dairy production • Suitable ecology and favourable climatic condition • Availability agro-industrial by-products (brewery, flour mills and sugar industry) • High milk prices • Possibility to obtain grass from coffee plantations • Vet clinics are present and this cluster is the host of the national lab for *Trypanosomiasis*	• Lack of developed market outlets for milk and dairy products. • Inefficient and inadequate milk processing technologies, • Poor quality and quantity of feed, lack of forage improvement programs • Less intervention from public sector and NGO's • Poor dairy extension services • High disease prevalence especially improved breeds (local breeds more adapted) • Ineffective and inefficient veterinary services, poor quality of drugs supply, etc. • Poor genetic improvement program

Most needed investment areas: input service provision (vet, AI, extension), fodder improvement, processing capacity.

4.3.4 Adama (Nazret) -Asela

Farming system		Explanation
Mixed crop-livestock	80 %	traditional midland/highland mixed farming
Urban / Peri-urban	18 %	emerging smallholders specialized in dairy
Specialized commercial	2 %	intensive dairy farming
Cattle		
Indigenous	%	
Improved breeds	%	

Developments in dairy sector

The cluster has one liquid nitrogen plant in Asela and one genetic improvement ranch in Ada Mitulu.

Strong	Weak
• High milk consumption per capita: milk is used as coffee creamer • Increasing population and urbanisation • Good cooperatives and private investors that transport milk and dairy products to Addis • Conducive agro-ecology, and environment and temperature • Infrastructure development (all weather roads) • Large cattle population • Availability of labour • Availability of trained community AI technicians (private farmers) with high success rates • Integrated agro industrial park being established • Presence of agro-industrial by-products (flour mills and sugar industry)	• Low productivity of cows • Limited genetic potential for dairy (dominance of local breed) • Feed availability and quality; less production of food crops means less by-products; tradition of burning wheat straw; high transportation costs for fodder • Weak extension capacity • Milk collection is limited to the road side • Milk production is not commercially oriented • Shortage in water supply (rain and irrigation) • Lack of appropriate post-harvest technology (no processors in the cluster) • Limited availability of land for grazing and fodder • Poor market development, inadequate supply of input and logistics for delivery of activities, less market oriented farmers

Most needed investment areas: genetic improvement, feed and fodder management, supply chain development.

4.3.5 West & East Hararghe

Farming system		Explanation
Mixed crop-livestock	98 %	traditional midland/highland mixed farming (1500 – 2000 meters above sea level)
Urban / Peri-urban	2 %	emerging smallholders specialized in dairy
Specialized commercial	0 %	
Cattle		
Indigenous	%	
Improved breeds	%	

The cluster has one liquid nitrogen plant in Hirna.

Strong	Weak
• Functional informal market for milk • Available agro-industrial by-products (flour mills and beer industry Harar beer factory) • Jijiga has a moderate climate and good potential for dairy. At present most of the dairy consumed comes from camels	• Poor knowledge of farmers on modern animal husbandry and management, • Weak extension system • Poor development of the formal market, lack of milk collection centres, chilling centres and transportation facilities • Scarcity of improved breeds, dependence on indigenous breeds • Inefficient and untimely artificial insemination (AI) services and poor semen quality • Impact of climate change is affecting feed availability (seasonal variations) • Critical problems with water supply (rain and irrigation)

Most needed investment areas: input services (extension, vet, AI), supply chain development, irrigation and water management.

Small-scale milk processing plant.

4.4 Clusters SNNPS

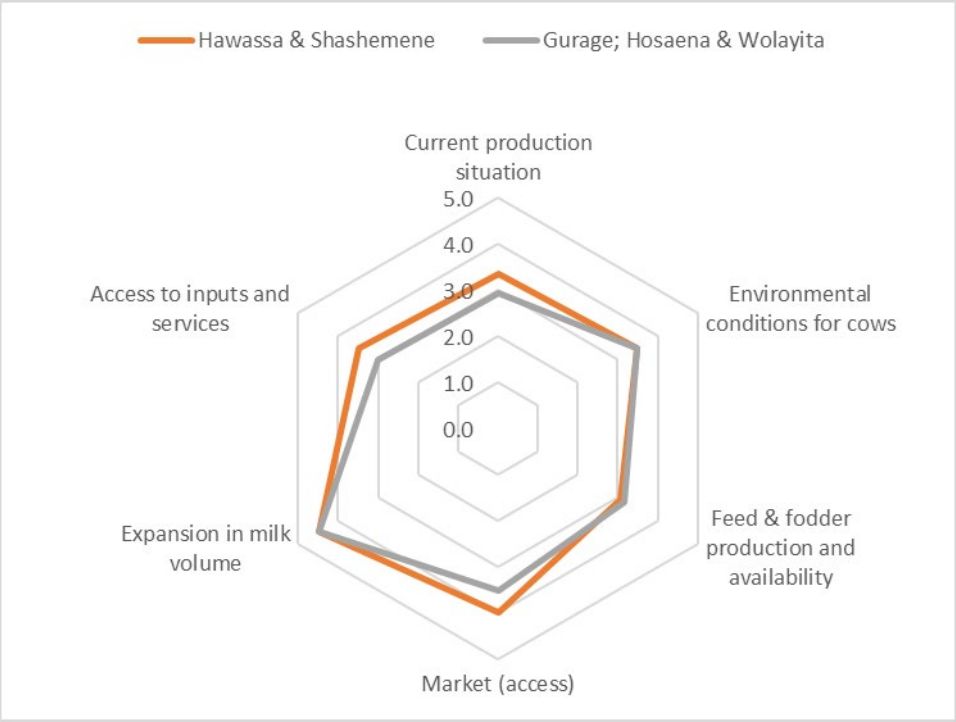

Figure 16: Benchmarking clusters in the SNNPS.

Based on the web chart, clusters in SNNPS have almost similar potentials for dairy production. However, the Hawassa – Shashemene cluster has a little more access to the market for both the inputs and milk products and also a higher current production of milk compared to Gurage; Hosaena & Wolayita.

4.4.1 Gurage: Hosaena & Wolayita

Farming system		Explanation
Agro-pastoral	5 %	traditional lowland crop-livestock farming
Mixed crop-livestock	90 %	traditional midland/highland mixed farming
Urban / Peri-urban	5 %	emerging smallholders specialized in dairy
Specialized commercial	0 %	
Average farm size	0.5 ha	
Cattle		
Herd size: > 5 cows	2 %	
Indigenous	94 %	
Improved breeds	6 %	

Developments in dairy sector

There are two modern milk processing plants each with capacity of 10,000 litres per day. The cluster also has few private investors with a herd size 20 -30 cows. The formal milk market accounts for about 2% of the total milk production. Most of the remaining milk is processed traditionally. There are four food processors in the cluster producing agro-industrial by-products. The cluster has three (Wolkite, Hadiya and Wolaita) nitrogen plants and one bull dam farm.

Strong	Weak
• High current and potential cattle population • Relatively high milk yield per cow • Relatively high proportion of improved breed • Proximity to market • Suitable climate for dairy • Water is available from many streams and can be used for irrigation • Feed and fodder production and crop residues available (wheat, barley, and teff). • One beer factory • Innovative farmers willingness to adopt new technologies, open minded people	• High population density with less land availability and competition in land use with crops • AI services not always available, use of bulls • Very high milk prices, high variation in prices between seasons and from place to place within the cluster • Predominantly traditional systems • Poor animal management, long calving interval and expensive heifer price (60,000 ETB). • Feed expensive (relatively higher cost of production)

Most needed investment areas: service provision (AI, vet), herd management, feed management.

4.4.2 Hawassa – Shashemene

Farming system		Explanation
Agro-pastoral	3 %	traditional lowland agro-pastoral farms
Mixed crop-livestock	93 %	
Urban / Peri-urban	4 %	emerging smallholders specialized in dairy
Specialized commercial	0 %	
Average farm size	1 ha	
Cattle		
Herd size: > 5 cows	± 5 %	
Indigenous	87 %	
Improved breeds	13 %	

Developments in dairy sector

The cluster has one dairy processing plant in Hawassa, four feed processing plants, two research centres (working mainly on forage), one nitrogen plant and one semen collection centre. It also has 73 milk collection centres and a very high average farm gate milk price of 16 – 30 ETB per litre.

Strong	Weak
• High cow population • Relatively high milk yield per cow • Suitable climate for dairy • High demand for high value dairy products in local hotels • The largest agro-industrial park is under construction in this cluster	• Small herd size • High feed prices • High transportation cost for feed • High fluctuation in milk price • Predominantly a coffee production area, less forage land, less availability of crop residues • Less experienced AI and vet technicians • Tsetse flies are prevalent in this cluster • Poorly developed dairy chain, lack of appropriate milk equipment for churning, chilling facilities and collection centres

Most needed investment areas: genetic improvement targeting yield improvement and disease resistance, feed and fodder management, supply chain development.

4.5 Final conclusions reflecting on all cluster assessments

Feed and fodder availability, quality and price have been identified as major factors contributing to the milk production potential of a cluster. The weather and climate of a cluster does not only influence its potential to produce feed, but also the possibility for animals to perform optimally. If crop production is common in a cluster, the chance of getting by-products for feeding animals increases. However, when crop production is strongly prioritised in a cluster, land may become limited and less competitive for grazing and fodder production.

Feed and fodder can be transported from areas having a surplus to areas having a deficit. However, due to the high transportation costs, the radius within which transportation is economically feasible will be limited, especially if the purchased volumes are small.

Demand for milk and dairy products is a driver for production and the development of the dairy chain. Fluctuation in milk prices between fasting and non-fasting periods caused by a change in demand affects dairy development. Production of long shelf life products during the fasting period to serve the non-fasting period might be an option to reduce seasonality in demand for dairy products and hence promote sector development. However, the demand for these product needs to be there too.

Medium large scale dariy farm.

Appendix 1 Applied methodology

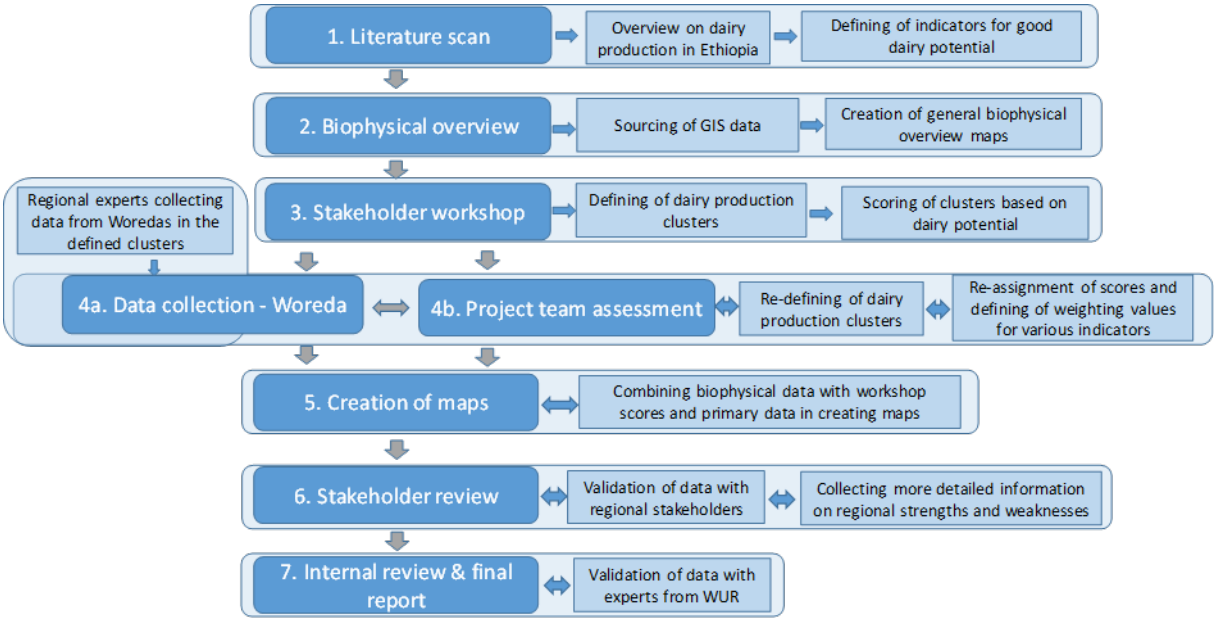

Figure A1: Steps in the applied approach.

The study involved seven steps as shown in the figure above. A **literature scan** was conducted from various secondary sources, giving an overview of dairy production and also identifying the indicators for distinguishing areas with a good dairy potential. Data was also sourced from GIS sources and used in creating a general **biophysical overview** for the whole of Ethiopia.

This was followed by a **stakeholder workshop** where the expertise from national and regional experts was used in combination to the biophysical overview, in defining clusters with a high dairy production potential in Ethiopia. This was followed by a scoring of the clusters based on the indicators defined in step 1.

Regional experts carried out **data collection at woreda** level for Woredas within the selected clusters and the **project team made an assessment** of all collected data leading to a redefinition of the borders of some clusters and adjustments of the initial scores on indicators.

The team also assigned weighting factors to these indicators considering the importance of each to contribute to the potential of dairy development. The outcome of the project team assessment was a combination of biophysical data and primary data from experts was used in **creating maps** showing milk potential. These maps were presented and validated in **stakeholder review meetings** involving regional and national experts (see Appendix 3) who also provided additional information about strengths and weaknesses of various clusters.
Finally, an **internal review** was done by experts from Wageningen University & Research leading to the production of this final report.

Method of scoring
Weighting factors were assigned to each criterion by four separate national experts. The differences in weighting was discussed until a consensus was reached on the scores. The criteria and scores are described in table below.

Table A1: Description of the scoring criteria and weighting of scores for various clusters

	Criterion	*Score of 5 =*	*Weight*	*Explanation*
	Current production situation			
1	Milk volume (formal and informal)	*High*	*8*	*Total amount of milk produced in the cluster in kg*
2	% of milk to formal market	*High*	*3*	*% of milk that is delivered to milk processors. The rest of the milk is consumed by the owners family or sold in the neighbourhood*
3	Number of cattle	*High*	*2*	*Total number of cattle in the cluster*
4	Number of dairy cows	*High*	*5*	*Total number of dairy cows in the cluster*
5	Number of improved dairy cows	*High*	*2*	*% of improved dairy cows in the cluster*
	Environmental conditions for cows			
6	Climate conditions for dairy cows	*Ideal*	*5*	*Climate conditions based only on heat stress on an annual base* *1= little heat stress, 5= more than 5 months with heat stress*
7	Animal health risks	*Low*	*5*	*Based on the prevalence of ticks, FMD and other diseases*
	Feed & fodder production and availability			
8	Availability and affordability of agricultural land	*Very positive*	*10*	
9	Biomass production per ha (fodder potential)	*High*	*15*	*Biomass production ability*
10	Availability of roughage and crop residues	*High*	*6*	*Availability of grass, fodder crops (maize, sorghum, fodder beets, etc.) and crop residues*
11	Availability of by-product brewers grain	*High*	*2*	*Availability of brewers grains from distilleries*
12	Availability of by-products oil seed cakes and wheat meal	*High*	*2*	*Availability of by-products from humane food factories*
	Market (access)			
13	Distance to main road	*Short*	*5*	
14	Distance to closest chilling center or processing plant	*Short*	*5*	
	Expansion in milk volume			
15	Expected growth in formal milk market	*High*	*5*	
16	Attitude of authorities towards increase in milk production	*Very positive*	*2*	
17	Attitude of farmers towards increase in milk production	*Very positive*	*5*	
18	Potential for future expansion of dairy farms	*High*	*3*	
	Access to inputs and services			
19	Distance to closest feed factory	*Easy access*	*2*	
20	Skilled dairy workers	*Easy access*	*1*	
21	Vet	*Easy access*	*2*	
22	Insemination	*Easy access*	*1*	
23	Extension private service	*Easy access*	*2*	*Private services are mainly targeting commercial farmers*
24	Electricity coverage	*High*	*2*	*Is there reliable access to electricity on the farm? (% coverage might be an easier indicator and could probably be optioned from GIS data)*

Appendix 2 Expert judgement on potential of dairy clusters

	Region	Weigh-ting (total = 100%)	Tigray	Tigray	Tigray	Tigray	Amhara	Amhara	Amhara	Amhara & Oromia	Oromia	Oromia	Oromia	Oromia & Somali	SNNP	SNNP & Oromia
	Indicator **Name Dairy Cluster**		Inda Silase - Axum	Mekelle - Adigrat	Maychew	Humera	Gondar - Debre Tabor	Weldiya - Dese - Kemise	Bahir Dar - Debre Markos	North Shewa	South- & West Shewa - Shambu	Jimma & Metu	Adama - Arsi - Robé	East- & West Hararghe	Gurage; Hosaena & Wolayita	Hawassa & Shashemene
	a) Current production situation															
1	Milk volume (formal and informal)	8	3	3	2	4	3	2	3	5	4	2	4	2	3	3
2	% of milk to formal market	3	1	2	1	1	2	1	2	4	3	1	3	1	2	3
3	Number of cattle	2	3	3	3	4	5	3	5	4	3	5	5	3	3	3
4	Number of dairy cows	5	3	3	3	4	5	3	3	4	3	4	5	3	3	4
5	Number of improved dairy cows	2	3	4	2	1	3	3	3	5	3	1	5	3	4	4
	Sum of weighted scores	*20%*	*11*	*12*	*9*	*13*	*14*	*9*	*12*	*18*	*14*	*10*	*17*	*9*	*12*	*13*
	Average score (on a scale of 5)		***2.7***	***3.0***	***2.2***	***3.3***	***3.6***	***2.3***	***3.1***	***4.5***	***3.4***	***2.6***	***4.3***	***2.3***	***3.0***	***3.4***
	b) Environmental conditions for cows															
6	Climate conditions for dairy cows	5	4	4	3	2	4	3	4	5	4	4	4	3	4	4
7	Animal health risks	5	4	4	3	2	3	3	2	5	4	3	5	3	3	3
	Sum of weighted scores	*10%*	*8*	*8*	*6*	*4*	*7*	*6*	*6*	*10*	*8*	*7*	*9*	*6*	*7*	*7*
	Average score (on a scale of 5)		***4.0***	***4.0***	***3.0***	***2.0***	***3.5***	***3.0***	***3.0***	***5.0***	***4.0***	***3.5***	***4.5***	***3.0***	***3.5***	***3.5***
	c) Feed & fodder production and availability															
8	Availability and affordability of agricultural land	10	4	2	3	5	3	2	3	3	4	3	3	2	3	3
9	Biomass production per ha (fodder potential)	15	3	2	2	4	3	3	4	4	4	4	5	3	3	3
10	Availability of roughage and crop residues	6	3	2	4	4	3	3	4	4	4	4	5	3	4	3
11	Availability of by-product brewers grain	2	1	2	4	1	3	4	1	5	4	3	4	2	2	3
12	Availability of by-products oil seed cakes and wheat meal	2	3	4	2	3	3	3	3	4	2	1	5	2	4	4
	Sum of weighted scores	*35%*	*22*	*15*	*19*	*28*	*21*	*19*	*24*	*26*	*27*	*24*	*31*	*18*	*22*	*21*
	Average score (on a scale of 5)		***3.2***	***2.1***	***2.7***	***4.1***	***3.0***	***2.8***	***3.5***	***3.8***	***3.9***	***3.5***	***4.4***	***2.6***	***3.2***	***3.1***
	d) Market (access)															
13	Distance to main road	5	3	4	3	2	4	4	4	5	4	3	4	3	4	4
14	Distance to closest chilling center or processing plant	5	2	3	3	1	3	2	3	5	5	1	4	2	3	4
	Sum of weighted scores	*10%*	*5*	*7*	*6*	*3*	*7*	*6*	*7*	*10*	*9*	*4*	*8*	*5*	*7*	*8*
	Average score (on a scale of 5)		***2.5***	***3.5***	***3***	***1.5***	***3.5***	***3***	***3.5***	***5***	***4.5***	***2***	***4***	***2.5***	***3.5***	***4***
	e) Expansion in milk volume															
15	Expected growth in formal milk market	5	4	4	3	4	3	2	4	5	5	2	5	3	4	4
16	Attitude of authorities towards increase in milk production	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5
17	Attitude of farmers towards increase in milk production	5	5	5	4	3	5	5	5	5	5	5	5	5	5	5
18	Potential for future expansion of dairy farms	3	4	3	4	4	3	3	4	5	3	3	4	3	4	4
	Sum of weighted scores	*15%*	*13*	*13*	*11*	*11*	*12*	*11*	*13*	*15*	*14*	*11*	*14*	*12*	*13*	*13*
	Average score (on a scale of 5)		***4.5***	***4.3***	***3.8***	***3.8***	***3.9***	***3.6***	***4.5***	***5.0***	***4.6***	***3.6***	***4.8***	***3.9***	***4.5***	***4.5***
	f) Access to inputs and services															
19	Distance to closest feed factory	2	2	4	3	1	3	2	3	5	5	1	5	2	2	4
20	Skilled dairy workers	1	3	4	3	2	3	3	4	5	5	3	5	3	3	3
21	Vet	2	3	4	3	2	3	3	4	5	4	3	5	3	3	3
22	Insemination	1	2	4	3	1	2	2	3	5	5	2	5	3	3	4
23	Extension services	2	3	4	3	1	3	3	3	3	4	3	3	3	3	3
24	Electricity coverage	2	4	5	4	2	4	4	4	4	4	4	4	4	4	4
	Sum of weighted scores	*10%*	*6*	*8*	*6*	*3*	*6*	*6*	*7*	*9*	*9*	*5*	*9*	*6*	*6*	*7*
	Average score (on a scale of 5)		***2.9***	***4.2***	***3.2***	***1.5***	***3.1***	***2.9***	***3.5***	***4.4***	***4.4***	***2.7***	***4.4***	***3.0***	***3.0***	***3.5***
	Total overall score	**100%**	**3.26**	**3.14**	**2.89**	**3.14**	**3.36**	**2.86**	**3.50**	**4.41**	**4.02**	**3.09**	**4.40**	**2.81**	**3.37**	**3.51**

Appendix 3 Assessing heat stress vulnerability

During the summer months heat stress affects dairy cows and other domestic animals in tropical, sub-tropical and sometimes temperate regions of the world. Heat and humidity creates a sub-optimal condition for dairy cows to produce milk.
The optimal thermal zone of dairy cows ranges from ca. 0°C to 22°C. If it becomes warmer cows begin to alter their basal metabolism and metabolic rate. Combined with high humidity levels the effect of heat stress increases.
Figure A2-1 demonstrates how the combined effects of temperature and relative humidity induce heat stress of dairy cows and the severity of heat stress.

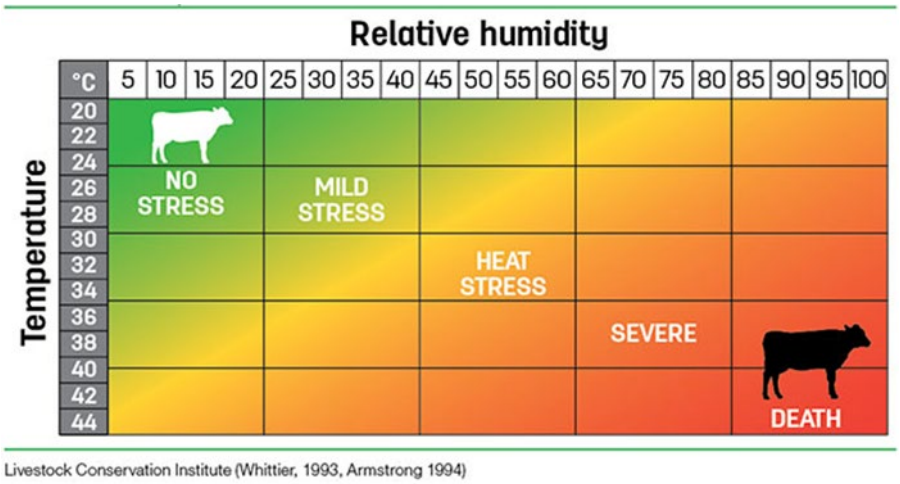

Figure A2-1: Illustration of combined effects of temperature and relative humidity on heat stress of dairy cows.

An index to estimate heat stress was developed combining relative humidity (vapour pressure in kPa) and monthly mean temperature (°C). This index is called Temperature Humidity Index (THI) is based on www.worldclim.org and can be calculated as:

$$THI = (1.8xT + 32) - ((0.55 - 0.0055xRH) \times (1.8xT - 26))$$

Where: T = Temperature in °C, and RH = Relative Humidity in %.

Monthly mean temperature was combined with monthly vapour pressure data. Using these monthly values per km^2 the mean THI score per month was extracted. Figure A2-2. shows the degree of heat stress that cows will be exposed to. High producing dairy cows begin to decline production at an average THI of 68. When the index ranges from 72 to 79 cows begin to suffer, and milk production drops rapidly. At THI of more than 80 cows become severely stressed and will not produce milk anymore. In many temperate regions of the world where summers are mild and temperature rarely exceeds 30°C, moderate to severe episodes of heat stress can occur due to high humidity. THI index of 75 or above can occur when temperature is 27°C, combined with a humidity above 80%.

Second step was to aggregate these values per woreda taking the monthly mean THI-values of all km^2s (see Figure A2-2). Based on the monthly THI scores per woreda, the maximum THI score per season was calculated, thus showing a maximum average observed THI level per season. Using the average monthly scores THI levels will be, to a certain degree, an

underestimation of the local maximum reached values within a woreda per season.

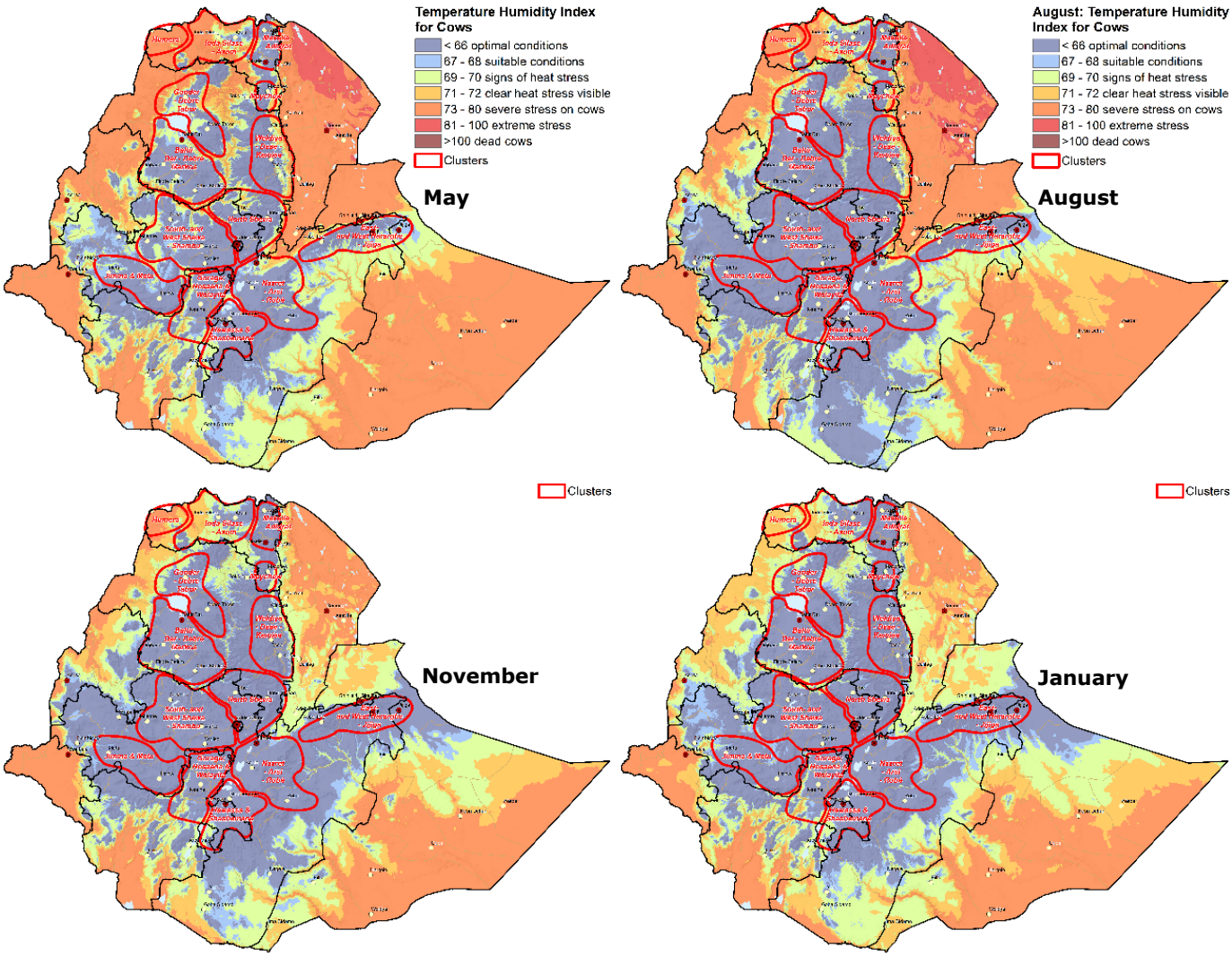

Figure A2-2: Temperature humidity index (THI).

Figure A2-2 shows that all selected dairy clusters, except the 'Humera' cluster, are less vulnerable for heat stress, making them more appropriate for dairy production, especially if milk is produced by improved breeds. Indigenous breeds and crossbreeds are usually more adapted to heat stress. The presence of these breeds in the 'Humera' cluster was the reason for the involvement of this cluster in the report.

For the classification of Figure A2-2 the following five classes per season where extracted:

THI > 76 = Class & value 0;
THI > 72 = Class & value 1;
THI > 68 = Class & value 2;
THI > 66 = Class & value 3;
Other = Class & value 4.

In Figure 7 (see Chapter 3) the final value per year is the average value over all four seasons. If the average maximum THI in four seasons >72 (Class 0 or 1) this is classified as "Very High THI scores", if THI is Class 2 this is classified as "High THI scores", all other classes are classified as "Good".

Appendix 4 List of experts consulted

The authors are grateful for the support of local dairy consultants who have greatly contributed to providing data and qualitative information about the dairy clusters:

1. Tolera Debela, Oromia livestock and fishery development Bureau, senior dairy development expert
2. Degu Tolera, Finifine surrounding zone livestock and fishery development office, dairy development expert
3. Wolde Kebede, SNNPRS Livestock and fishery development Bureau, senior livestock development expert
4. Musie Girmay, Tigray Agriculture and Natural resource development bureau, Senior Dairy expert
5. Ahmed Alkader, Amhara Livestock resource production and promotion Agency, senior expert
6. Gebremedhine Beyene, Mekelle University . Department of Animal, Rangeland and Wildlife Sciences (ARWS), instructor and postgraduate program coordinator
7. Dr. Bimrew Asmare, Bahir Dar University
8. Tariku Teka, Ministry of Agriculture and Livestock development, Director, Dairy Development directorate
9. Abebe Tesema, Dairy consultant
10. Alemayew Tadesse, Mekelle University, PhD candidate
11. Yemane WoldeGebriel, Dairy business consultant
12. Ahmed Alkader, Amhara Livestock resource production and promotion Agency, senior expert
13. Degu Addis Abune, Dairy business consultant
14. Sileshi Yeseral, Andasa Agricultural research centre, livestock researcher
15. Kedjela Tesema, Oromia livestock and fishery development Bureau, dairy development expert
16. Abera Ketema, Oromia livestock and fishery development Bureau, dairy development expert
17. Wolde Kebede, SNNPRS Livestock and fishery development Bureau, senior livestock development expert
18. Shenkoru Morka, SNNPRS Livestock and fishery development Bureau, senior livestock development expert
19. Abreham Nathealem, Dairy consultant

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To explore the potential of nature to improve the quality of life

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Wageningen Livestock Research creates science based solutions for a sustainable and profitable livestock sector. Together with our clients, we integrate scientific knowledge and practical experience to develop livestock concepts for future generations.

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