NTFP–PFM
South-West Ethiopia
Forested Landscapes and Livelihoods

Embassy of the
Kingdom of the Netherlands

ATLAS OF MAPS
LAND COVER CHANGE
1973 – 2009

Mizen Teferi,

January 2010

The project is implemented with financial contributions from the European Union's Environment Budget Line and with additional funding from the Embassies of the Netherlands and Norway in Ethiopia. The authors are solely responsible for the opinions expressed in this document, and they do not necessarily reflect those of the European Union, the Netherlands Embassy or the Norwegian Embassy.

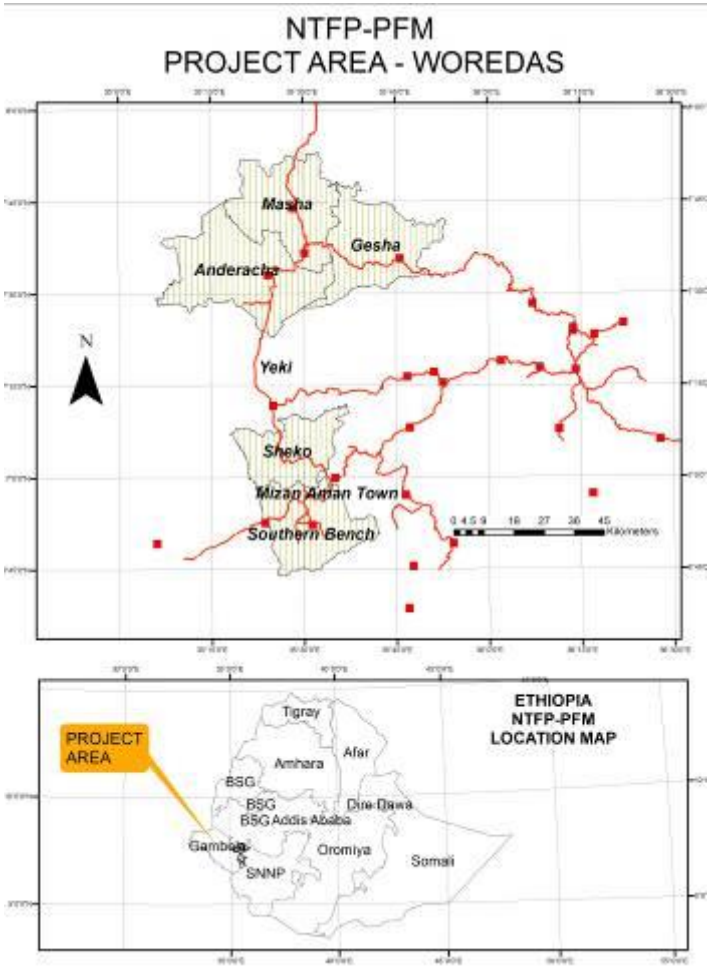
1. PROJECT AREA

The Project is located in the Southwest Highlands of Ethiopia, in the north-western part of the Southern Nations, Nationalities and Peoples Regional State (SNNPRS) (see Map X). It focuses on five *woredas*[1]: Anderacha and Masha *woredas* in Sheka Administrative Zone, Gesha *woreda* in Kefa Administrative Zone and South Bench and Sheko *woredas* in Bench-Maji administrative Zone

The three northern *woredas,* Anderacha, Masha and Gesha, cover an area of 216,296 km2 and the two in the south cover 131,085 km2. The rainfall pattern is uni-modal from March through to October although rain can fall in any month. Over these target *woredas* mean annual rainfall is between 1,700 to 2,500 mm. Mean annual temperatures are governed largely by altitude, being between 13° and 17° C.

The Project area in the north comprises an undulating plateau between 2,100 and 2,500 masl. To the north a short escarpment leads to lower ground between 1,700 and 1,900 masl and to the Baro River and its tributaries and to the west a major escarpment separates the main plateau from the Gambella lowlands at between 800 and 1,100 masl. The area in the south comprises a dissected plateau between 1,100 and 1,900 masl, with an escarpment to the lowlands of the Akobo Sub-basin.

[1] **"*Woreda*" is an administrative unit equivalent to District.**


NTFP-PFM
PROJECT AREA - WOREDAS
Masha
Gesha
Anderacha
N
Yeki
Sheko
Mizan Aman Town
Southern Bench
0 4.5 9 18 27 36 45
Kilometers
ETHIOPIA
NTFP-PFM
LOCATION MAP
PROJECT AREA
Tigray
Afar
Amhara
BSG
BSG
Dire Dawa
BSG Addis Ababa
Gambela
Oromiya
Somali
SNNP

2. METHODOLOGY

Landcover mapping was undertaken using Landsat imagery for 1973, 1987, 2001 and 2009. The 2009 imagery suffers from missing data because a fault in the satellite scanner. In addition some of the highest areas had patches of cloud cover. Use had to be made of the cloud free 2001 image to fill in the missing data gaps.

A total of 270 ground checks were made with positions located using a GPS. The locations were subsequently converted to vector point files and overlain on the Satellite images to aid interpretation. It was not possible to distinguish degrees of disturbance in the Forest category from the satellite image. Thus, only one Forest category was mapped. Areas of Wetlands, Bamboo, Bamboo + trees, Coffee and Tea Estates were interpreted directly from the satellite image and were then masked from a colour composite of bands 4, 7 and 1 of the image. A supervised classification was then undertaken of the remaining land cover classes (forest, agriculture and grassland) from training sites identified on the colour composite using all six bands in the "MAXIMUM LIKELIHOOD" routine in IDRISI Taiga. The "SEGMENTATION" routine was then used to group adjacent pixels into similar segments according to their spectral similarity.

3. MAIN LAND COVER TYPES

3.1 FORESTS

The main forest types are correlated strongly with altitude (Friis, 1992):

- Medium altitude (1,100 – 1,950 masl) Broadleaved Afro-montane (transitional) forest (with coffee),
- Higher altitude (1,950 – 2,500 masl) Broadleaved Afro-montane forest without coffee;
- Pure stands of Highland Bamboo (*Arundinaria alpina*) forest between 2,500 – 2,750 masl

The Higher altitude Afro-montane forest is mainly found in the three northern woredas, whilst the Transitional Forest is found in the two southern woredas. The main coffee growing areas are found in these two southern woredas.

(i) Medium altitude Broadleaved Afro-montane forest (with coffee)

This is also known as "Transitional" forest because it contains some species of trees from the Lowland Guinea-Congo Rain Forest found below 1,100 masl just to the west of the Project Area and species from the higher altitude Afro-Montane Forest..

Both medium and higher altitude Afro-Montane forest becomes more diverse in species from east to west (i.e. with increasing rainfall) and with decreasing altitude (i.e. with increasing temperature). Forests in the Baro catchment are thus floristically richer than in the Omo catchments.

Three forest coffee ecosystems have been recognized (Feyera, Senbeta and Denich, 2006):

(i) Undisturbed wild coffee forest which only involves harvesting of wild coffee,
(ii) (ii) Semi-forest coffee which involves clearing of the under-storey and thinning of larger trees, and
(iii) (iii) Semi-forest coffee plantations which involve modification of forest vegetation as with semi-forest coffee but with the addition of seedlings either from undisturbed coffee forest or from traditional or modern cultivars from nurseries.

A fourth coffee cultivation system is the homestead garden coffee garden under natural or planted shade trees.

Figure 1. Semi-Forest-Coffee Forest

The three categories of coffee forest were found to differ considerably in the degree of human alteration of the original wild coffee forest and thus in terms of their relative importance for conservation of their coffee gene pool**.**

Higher Altitude Afro-montane (Cloud) Forest (No coffee)

Four strata can be generally recognized. The highest stratum is formed by trees 30 to 50 m high, the most important of which are *Aningeria adolfi-friederici*, which is the main emergent, *and Ficus spp,* and *Syzygium guineense*. Below this is a dense stratum of trees 18 to 25 m high with a wide range of species. The third stratum of small trees and bushes includes *Galinera coffeodes* and *Coffea arabica*. *Coffee arabica* is not found above 1,900 masl in its wild state. The ground stratum includes *Aframomum korarima* and long pepper, important local spices. Epiphytes, especially mosses and Hymenophylaceae and Cyateacea (tree ferns) are very common (Figures 2 and 3).

Figure 2. Mosses are abundant in the Cloud Forest

Figure 3. Tree ferns (*Cyathea manniana*) are also very common.

Highland Bamboo (*Arundinaria alpina*)

Highland bamboo is found above 2,450 masl on a broad plateau in Masha and Anderecha *woredas* that overlooks the Gambella Lowlands. After a number of years (variously put at between 20 and 50 years) the bamboo flowers then dies in large areas. Recovery takes about 2 to 4 years. Currently, the bamboo is used only locally, mainly for fencing and house construction. Highland Bamboo in the Project area covers some 11,100 ha.

Figure 4. Highland Bamboo (*Arundinaria alpina*)

(iv) Agro-Forestry Landscapes of South Bench and Sheko Woredas (the southern area)

Generally the target kebelles lie between 1,100 and 1,700 masl and are thus well within the wild coffee zone. The agricultural/settlement landscape is quite distinct from the forest landscapes. The settlement/agricultural landscape has a number of landscape elements. The homestead and homestead gardens are quite distinct from cropland and from the grazing lands. Homesteads are generally located along the ridges. Water supply was reported to be a problem. The homestead gardens are quite complex and exhibit a number of elements:

- Enset garden: small number of plants (10-30)
- Small vegetable patch (local cabbage, taro, beans, sweet potato, onions, peppers)
- Fruit (mango, papaya)
- Banana garden (10 – 30 plants)
- Coffee (little/no shade)
- Small Eucalyptus woodlots

Annual croplands are generally located on steep slopes below the ridge crests. Very occasionally Vetiver grass strips were seen. The main crop is maize with sorghum and more recently *teff*. Continuous cropping is practised with no fallowing. Fields are un-fenced.

Grazing lands are also located on the steep slopes (often more 30%) and are often infested with shrubs. Livestock feed and water supply were problems in the dry season. Grazing areas are unfenced. No homestead forage is cultivated.

Wetlands are used for maize and taro production. Problems are reported with over-drainage and loss of fertility (particularly important for taro).

Figure 5. Annual cropland on steep slopes in Shaiyta kebelle, Sheko Woreda. Note Vetiver grass trip in foreground.

(v) Agro-forestry Landscapes of Anderacha, Masha and Gesha Woredas (the northern area)

Much of the area of Anderacha, Masha and Gesha woredas is above the wild coffee zone. Compared with South Bench woreda the area of forest is significantly larger. The Agro-forestry landscapes and landscape elements exhibit some significant differences from those in Sheko and Bench woredas.

The homestead garden is dominated by enset with three to four times the number of plants found in the southern agro-landscape. Coffee is very minor (altitude is 2,200 masl) and where grown is for own-consumption only. Vegetable crops include taro and local cabbage.

Crop and grazing lands are invariably fenced often with Euphorbia spp. and bamboo at higher altitudes. The range of crops is wider than in the south: maize, *teff*, wheat, barley and pulses. Grazing fields are often individually owned. Many of the livestock are tethered when grazing. The farmers follow a field rotation of 1 year crops, next year grass, followed by crops again. There is also a crop rotation superimposed on the field rotation of maize, pulses, *teff* and then wheat or barley. Maize trash lines are used in *teff* fields only, farmers having recognized the higher erosion potential of a *teff* crop. These systems are extremely efficient in retaining and recycling soil organic matter and nutrients.

Figure 6. Enset gardens and Fenced Crop and Grassland Fields in Uwa kebelle, Masha Woreda.

Elsewhere many areas have fenced communal grazing fields that are generally not cropped. Along the main road between Masha and Gecha (Anderacha woreda) cabbages and Irish potatoes are common in many fields.

Eucalyptus woodlots are common and in Gesha woreda there are planted Highland bamboo patches.

4. LAND COVER CHANGE

4.1 TRENDS IN LAND COVER CHANGE

Trends in land cover change were derived from the interpretation of Landsat satellite images for the years 1973, 2001 and 2009.

Land cover changes in the Project Area are shown in Table 1. Total forest lost during the period 1973-2009 is 61,962 ha out of a total forest area in 1973 of 207,790 ha. The annual rates of change have varied between 1973 and 2001 and 2001 and 2009. It was 0.7%/yr in the first period and falling in the second to 0.1%/yr. There was also a loss of bamboo forest of 545 ha during the period 1973 – 2009. The main increase in land cover type is in agriculture, agro-forestry, coffee and tea plantation and Coffee Forest.

Tables 2 and 3 show the land cover changes by woreda in the northern and the southern areas respectively. There are clear differences in the rate of forest loss between the two areas.

In the northern area overall the rate of deforestation increased slightly from 0.6 to 0.9% between 1973 – 2001, and 2001 – 2009, although the rate decreased slightly in Gesha woreda possible due to an increasing shortage of forest cover in many kebelles (See Map 5). In the early 1980's there was some resettlement of peoples from northern Ethiopia into Anderacha and Masha woredas. Forest was cleared but after three or four years the areas were abandoned and reverted back to forest.

Whilst these percent figures appear low, in fact they refer to large areas of forest. The areas cleared equate to the current natural rate of population increase and the current land allocation rates per household.

In the southern Coffee Forest area the overall rate of deforestation in the past 8 years appears to have been reversed. All land allocation of forest land for annual cropping and grazing stopped in 2002 in both Project woredas. It is now recognised that, given the high market price for coffee, the Coffee Forest is too valuable to be converted to cropland. There is also an increasing land market for Coffee Forest land with prices of up to ETB 25,000/ha. Although illegal, land purchasers obtain *de facto* legal title by

paying Land Tax to the Bureau of Finance. Farmers are also increasing the amount of trees in their Homestead gardens as shade for coffee plants.

Whilst the rate of growth of tree cover may have increased over the past 8 years there is a severe danger that the intensive management of coffee trees may be leading to major degradation of the forest in the future as only mature trees remain and no saplings are allowed to grow.

4.2 PROXIMATE AND UNDERLYING CAUSES OF LAND COVER CHANGE

Following Geist and Lambin and (2001) these can be divided into two broad categories:

- Proximate Causes (Direct forces, Predisposing environmental factors)
- Underlying Causes (Driving Forces)

4.2.1 Proximate causes (Direct Forces and Agents)

The direct forces and the agents affecting forest landscapes within the project areas include the following:

- Clearing forest for traditional small-scale rainfed agriculture by local inhabitants,
- Clearing forest for traditional small-scale rainfed agriculture by informal immigrants - was common in the southern part of Project area but has now ceased,
- Clearing forest for traditional small-scale rainfed agriculture by government sponsored resettlement - occurred in the northern areas in the 1980's but has now ceased,
- Clearing forest for traditional small-scale rainfed agriculture by Tea and Coffee Estate workers - occurred just after the Estates were established but recent application for an expansion of land for estate workers has been refused by the authorities,

These activities result in a complete change of land cover from forest to agriculture (cropland, homestead gardens and grazing) and settlement. In addition there are "qualitative" changes in the forest structure and tree species composition to a lesser and greater degree. These changes are being effected through various activities including:

- Clearing ground-storey vegetation for wild coffee harvesting by local inhabitants and by outside purchasers of land – this was until recently confined to the southern part, but has recently increased in the northern area below 1,900 masl.,
- Tree thinning (reducing shade), clearing ground-storey vegetation and transplanting wild coffee seedlings for enhancing wild coffee production by local inhabitants and by outside purchasers of land,
- Tree thinning (reducing shade), clearing ground-storey vegetation, transplanting wild coffee seedlings and planting "improved" coffee seedling for coffee production by local inhabitants and by outside purchasers of land,
- Constructing bee hives in undisturbed forest by local inhabitants and damage caused by fires caused by harvesting of wild honey,
- Extraction of fuelwood and house construction wood by local inhabitants for own use and for sale by local inhabitants,
- Extraction of fuelwood and house construction wood by estate workers
- Clearing of forest for urban and other infrastructural (e.g. road) construction.

4.2.2 Underlying Causes (Driving Forces)

The underlying causes can form linked chains of some complexity, which are often non-linear and with feed-back loops. In the project area some of these have been identified as follows:

(i) Demographic

- Natural increase in local population (local and settler) and increasing agricultural land requirements for annual crops, perennial crops, grazing land and settlement,
- In-migration: both formal and informal resulting from areas of land scarcity and high population densities in other parts of SNNPR and Ethiopia was important in the past but now occurs outside the Project area;

- Increases in urban populations impacting on increased markets for food, bio-fuels and wood products from the surrounding rural areas (linked to economic factors),
- Low skill levels in rural populations and lack of off-farm employment opportunities (linked to economic factors) leading to need for agricultural land.

(ii) Economic

- Growth in market demand (local, national and inter-national) for agricultural goods leading to expansion of managed coffee forest,
- Lack of appreciation of total economic value (local, national, regional and global) of forests, forest products and services with government budgets determined by size of population only.

(iii) Technical

- Increased availability of "improved" coffee types (higher yielding, coffee berry disease resistant) and planting in wild coffee forests,
- Low level of agricultural technology (crops and livestock production) linked to poverty and lack of credit availability leads to greater land requirements,
- Inappropriate emphasis of official agricultural research and extension on annual crops to detriment of root crops, which are better suited to high rainfall areas.

(iv) Cultural

- Breakdown in traditional environmental protection institutions for forest conservation is particularly important in the northern Sheka areas,
- Breakdown in traditional natural resource access institutions (e.g. *kobo* system).

(v) Policy and Institutional

- Contradictions in the application of various sectoral policies (e.g. Forestry, Land Registration, Investment),

- Weak development of rules and regulations in forest and environmental conservation policy.

5. Conclusions

Removal of Montane Forest for cropland has largely ceased in the two southern woredas. This is due to the high value placed on the forest as shade for coffee cultivation. However, there are signs that the complete removal of undergrowth, and thus of regeneration trees, which will lead to major degradation of the forest as mature trees die off. Deforestation is taking place on the high ridge of land in forest above 1,900 masl, which is too high for coffee.

In the three northern woredas conversion of Montane Forest for agriculture and settlement continues, being highest in the woreda with the highest population density: Gesha woreda, and lowest in Anderacha woreda which has the lowest population density.

REFERENCES

Friis, I. 1992 "Forests and Forest Trees of Northeast Tropical Africa", HMSO, London.

Feyera, Senbeta and M. Denich, 2006 "Effects of wild coffee management on species diversity in the Afromontane rainforests of Ethiopia", Forest Ecology and Management 232, 68 – 74.

Table 1. Land Cover Changes 1973 – 2009: Total Project Area

TOTAL PROJECT AREA

	Forest		Agriculture		Grassland		Wetland		Bamboo		Bamboo + Trees		Coffee Estate		Tea Estate		Total
1973	311,141	74%	93,509	22%	2,589	0.6%	3,104	1%	11,304	3%	981	0%	0	0%	0	0.0%	**422,628**
2001	250,192	59%	148,881	35%	1,274	0.3%	3,764	1%	9,616	2%	1,123	0%	7,188	2%	590	0.1%	**422,628**
2009	249,178	59%	150,088	36%	898	0.2%	3,317	1%	10,760	3%	1,000	0%	6,746	2%	640	0.2%	**422,628**
	(61,962)		**56,578**		**(1,691)**		**213**		**(545)**		**20**		**6,746**		**640**		

	ha/yr	%
1973 - 2001	2,177	0.7%
2001 - 2009	127	0.1%
1973 - 2009	**1,721**	**0.6%**

Table 2. Land Cover Changes 1973 – 2009: Northern Project Area

ANDERACHA WOREDA	Forest		Agriculture		Grassland		Wetland		Bamboo		Bamboo+ trees		Coffee Estate		Tea Estate		TOTAL
1973	85,748	86%	9,258	9%	25	0%	0	0.0%	4,287	4%	816	1%	0	0.0%	0	0%	**100,134**
2001	86,589	86%	8,078	8%	0	0%	338	0.3%	3,663	4%	1,001	1%	465	0.5%	0	0%	**100,134**
2009	80,630	81%	13,073	13%	408	0%	372	0.4%	4,484	4%	849	1%	317	0.3%	0	0%	**100,134**

	ha/yr	%
1973 - 2001	-30	0.0%
2001 - 2009	745	0.9%
1973 - 2009	**142**	**0.2%**

GESHA WOREDA	Forest		Agriculture		Grassland		Wetland		Bamboo		Bamboo+ trees		Coffee Estate		Tea Estate		TOTAL
1973	58,572	82%	9,971	14%	0	0%	1,440	2%	1,341	2%	0	0%	0	0%	0	0%	**71,324**
2001	32,405	45%	36,276	51%	0	0%	2,001	3%	616	1%	27	0%	0	0%	0	0%	**71,324**
2009	29,132	41%	40,109	56%	0	0%	1,567	2%	490	1%	26	0%	0	0%	0	0%	**71,324**

	ha/yr	%
1973 - 2001	935	1.6%
2001 - 2009	409	1.3%
1973 - 2009	**818**	**1.4%**

MASHA WOREDA	Forest		Agriculture		Grassland		Wetland		Bamboo		Bamboo+ trees		Coffee Estate		Tea Estate		TOTAL
1973	63,469	83%	6,928	9%	0	0%	316	0%	5,512	7%	0	0%	0	0%	0	0%	**76,224**
2001	56,225	74%	13,679	18%	0	0%	665	1%	5,066	7%	0	0%	0	0%	590	1%	**76,224**
2009	53,435	70%	15,838	21%	0	0%	747	1%	5,564	7%	0	0%	0	0%	640	1%	**76,224**

	ha/yr	%
1973 - 2001	259	0.4%
2001 - 2009	349	0.6%
1973 - 2009	**279**	**0.4%**

NORTHERN AREA	Forest		Agriculture		Grassland		Wetland		Bamboo		Bamboo+ trees		Coffee Estate		Tea Estate		TOTAL
1973	207,789	84%	26,157	11%	25	0.0%	1,755	1%	11,140	4%	816	0%	0	0%	0	0%	**247,682**
2001	175,219	71%	58,033	23%	0	0.0%	3,003	1%	9,345	4%	1,028	0%	465	0%	590	0%	**247,682**
2009	163,198	66%	69,020	28%	408	0.2%	2,686	1%	10,537	4%	875	0%	317	0%	640	0%	**247,682**

Annual Forest Loss	ha/yr	%
1973 - 2001	1,163	0.6%
2001 - 2009	1,503	0.9%
1973 - 2009	**1,239**	**0.6%**

Table 3. Land Cover Changes 1973 – 2009: Southern Project Area

SHEKO WOREDA	Forest		Agriculture		Grassland		Wetland		Bamboo		Bamboo+ trees		Coffee Estate		Tea Estate		TOTAL
1973	36,408	73%	13,292	27%	125	0%	0	0%	0	0%	0	0%	0	0%	0	0%	**49,825**
2001	36,586	73%	13,227	27%	9	0%	0	0%	0	0%	0	0%	3	0%	0	0%	**49,825**
2009	36,327	73%	13,498	27%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	**49,825**

	ha/yr	%
1973 - 2001	-6	0.0%
2001 - 2009	32	0.1%
1973 - 2009	**2**	**0.0%**

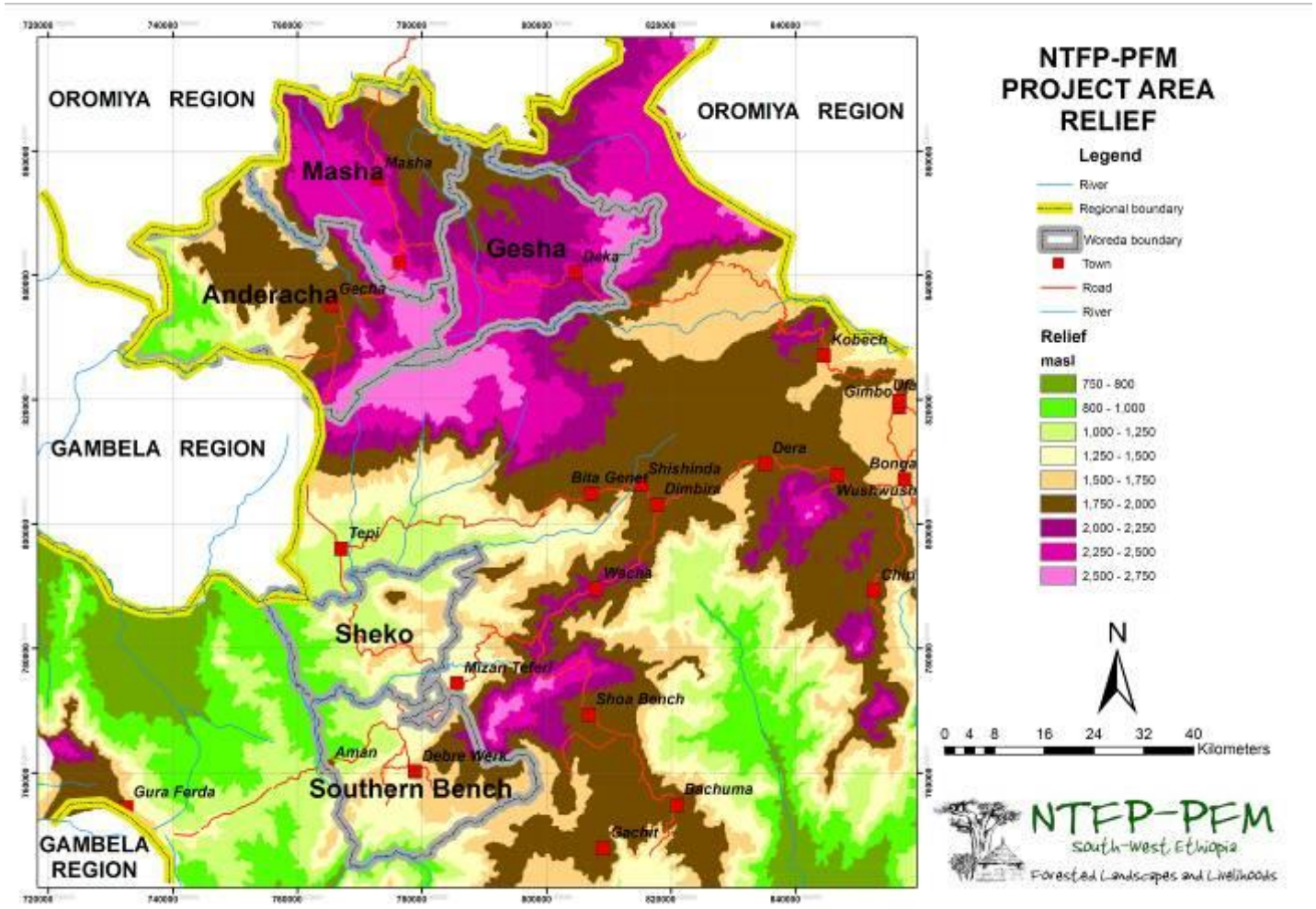
SOUTH BENCH WOREDA	Forest		Agriculture		Grassland		Wetland		Bamboo		Bamboo+ trees		Coffee Estate		Tea Estate		TOTAL
1973	22,671	36%	37,255	60%	1,889	3%	605	1%	0	0%	0	0%	0	0%	0	0%	**62,419**
2001	13,237	21%	42,538	68%	1,265	2%	562	1%	0	0%	0	0%	4,816	8%	0	0%	**62,419**
2009	18,358	29%	38,372	61%	471	1%	518	1%	0	0%	0	0%	4,700	8%	0	0%	**62,419**

	ha/yr	%
1973 - 2001	337	1.5%
2001 - 2009	-640	-4.8%
1973 - 2009	**120**	**0.5%**

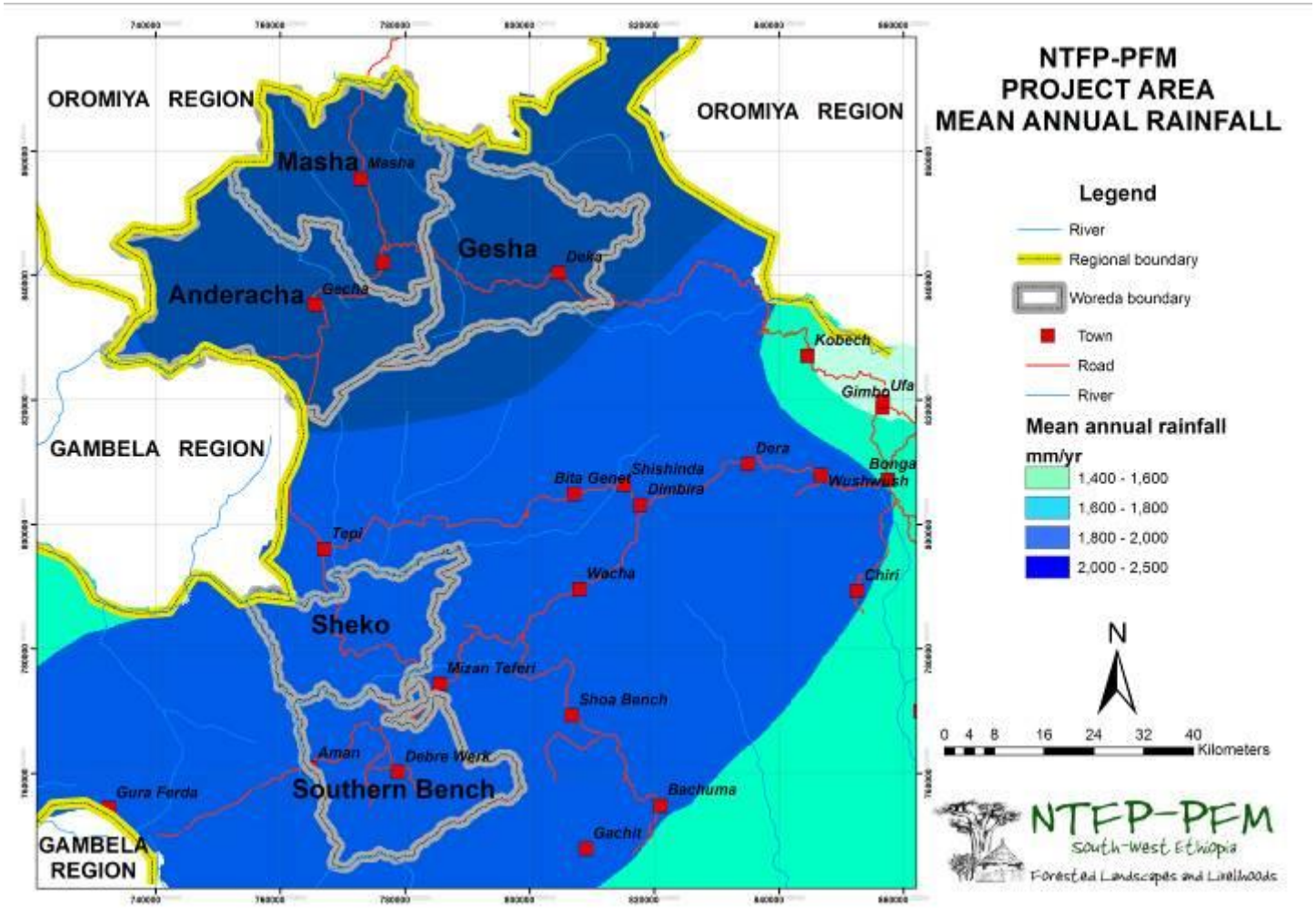
SOUTHERN AREA	Forest		Agriculture		Grassland		Wetland		Bamboo		Bamboo+ trees		Coffee Estate		Tea Estate		TOTAL
1973	59,078	53%	50,547	45%	2,014	2%	605	1%	0	0%	0	0%	0	0%	0	0%	**112,244**
2001	49,823	44%	55,765	50%	1,274	1%	562	1%	0	0%	0	0%	4,820	4%	0	0%	**112,244**
2009	54,685	49%	51,870	46%	471	0%	518	0%	0	0%	0	0%	4,700	4%	0	0%	**112,244**

	ha/yr	%
1973 - 2001	331	0.6%
2001 - 2009	-608	-1.2%
1973 - 2009	**122**	**0.2%**

MAP 1. NTFP-PFM PROJECT AREA: RELIEF



MAP 2. NTFP-PFM PROJECT AREA: MEAN ANNUAL RAINFALL


NTFP-PFM
PROJECT AREA
MEAN ANNUAL RAINFALL
OROMIYA REGION
OROMIYA REGION
GAMBELA REGION
GAMBELA REGION
Masha
Gesha
Anderacha
Sheko
Southern Bench
Kobech
Ufa
Gimbo
Dera
Bonga
Wushwush
Shishinda
Dimbira
Bita Genet
Tepi
Wacha
Chiri
Mizan Teferi
Shoa Bench
Debre Werk
Aman
Gura Ferda
Bachuma
Gachit
Legend
River
Regional boundary
Woreda boundary
Town
Road
River
Mean annual rainfall
mm/yr
1,400 - 1,600
1,600 - 1,800
1,800 - 2,000
2,000 - 2,500
N
0 4 8 16 24 32 40
Kilometers
NTFP-PFM
South-West Ethiopia
Forested Landscapes and Livelihoods