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REDD+ ETHIOPIA

Potential for Tree-Based Landscape Restoration (FLR) for Amhara Regional State

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Acronyms

AASA	Afroalpine/Sub-Afroalpine Ecosystems
AfR	Afforestation Reforestation
AgSLV	Agri-silvicultural Systems
BDPA	Biodiversity Priority Areas
CPE	Commercial Plantation
EFCCC	Environment Forest and Climate Change Commission of Ethiopia
FLR	Forest Landscape Restoration
HLBMB	Highland Bamboo
IMDNF	Improved Management of Degraded Natural Forest
Incense	Combretum Woodlands Restoration
LLBMB	Lowland Bamboo
Mha	Million hectares
Myrrh	Commiphora Woodlands Restoration
REDD	Reducing Emissions from Deforestation and Forest Degradation
RF	Religious Forest Management
Riverine	Riverine Forest
SILVO	Silvopastoral Systems
WLE	Woodlot Establishment
WRI	World Resources Institute
WWBF	Wetland and Waterbody Buffer

Executive Summary

Environmental deterioration and land degradation are two of the most pressing global environmental and developmental challenges of the 21st century. To curb these serious challenges, countries are developing various adaptation and mitigation programs and executing them in coordination with international collaborators. Ethiopia has launched several initiatives and programs to protect the environment and reduce land degradation as part of its growth and transformation plans (GTP) to boost the economic development of the country. One of the country's biggest initiatives is the climate resilient green economy (CRGE) strategy, which is part its economic development agenda. The government of Ethiopia is working in collaboration with an international alliance to enhance CRGE strategy and programming to respond to the above-mentioned climate challenges. One program affiliated with the CRGE is the forest landscape restoration (FLR) initiative. The FLR program was initiated by Environment, Forestry and Climate Change Commission (EFCCC) and the World Resources Institute (WRI) in 2016, with the goal of identifying forest landscape restoration options at the national level (MEFCC, 2018). This regional study is part refining and improving the national forest landscape restoration work at a regional level by accommodating regional criteria, challenges and priorities working with local and regional partners.

World Resources Institute, in partnership with the EFCCC and the Amhara regional REDD+ team, carried out this regional study. Participatory planning and validation workshops were conducted with regional stakeholders selected by REDD+ team during the inception phase to support the whole process and near the end of the project to validate the outcome. During the participatory planning workshop in March 2019, participants identified seven restoration potential options and a set of mapping criteria for each option. Based on this recommendation, we identified and mapped suitable locations for those FLR options using ESRI GIS software. A second workshop was conducted in August 2019 in Bahir Dar to validate the preliminary results. Based on recommendations, final analysis was conducted which yielded 15 individual FLR options that also included non-tree-based interventions.

The total potential for all identified interventions, including non-tree-based restoration interventions was about 13 Mha (87%) of the region (table 4). This figure also includes biodiversity conservation areas and Afro/Sub-Afroalpine regions not suitable for tree-based interventions, which together amounts to about 3Mha. The former has legally designated restrictions and the latter is above the traditional (3,750m) threshold. Thus, the final potential for all tree-based restorations interventions is about 10Mha (67%). A lot of interventions overlap, which implies that multiple options compete for the same space or alternatively also it means that those areas are suitable for more two or more intervention types. This entails prioritization using additional non-biophysical criteria for final decision making. The total area where two or more interventions are overlapping is about 6Mha (41%). The total non-overlapping area available for all tree-based interventions is about 7Mha (46%), split among the 10 interventions (see table 4 for details).

1 Introduction

Ethiopia's current national development plan, the Growth and Transformation Plan-II (GTP-II), outlines a series of forest and land use sector goals for the Amhara region (Box 1). However, to achieve these targets, the region must overcome various socio-economic and environmental challenges within the forest and land use sector (Box 2). This analysis aims to support decision-making processes by regional stakeholders so that they can develop more effective and informed strategies and action plans to tackle the identified challenges and achieve the regional goals set in the GTP-II. This study builds on two similar studies, namely, the "National Potential and Priority Maps for Tree-based Landscape Restoration in Ethiopia (MEFCCC, 2018)[1] " and the "Forest Landscape Restoration in Amhara (Sophia C. et al., 2016)[2] ."

This work expands on previous Ethiopia's national restoration potential mapping by EFCCC and WRI and a regional work done by UNIQUE Forestry and Land Use company, Germany through increased engagement of local stakeholders and newer and more localized data into this analysis. To facilitate increased local engagement, two regional workshops were conducted in Bahir Dar city, Amhara region, where participants from multidisciplinary institutions were selected and become the core resource persons in identifying regional forest and land use sector goals, the main challenges in the sector, and identification of the restoration options and mapping criteria. Additionally, efforts were made to incorporate relevant, updated global and local data in the analysis. Key global datasets included in this study were, the Global Ecological Land Units (Sayre et al., 2014, Land productivity Dynamics (Trends.Earth, Conservation International, 2018), and Normalized Difference Vegetation Index (Didan, K., 2015). As a result, we expect significantly improved results compared to previous studies. The ancillary data from USGS will also be used during field validation and prioritization of overlapping or competing potential forest and landscape restoration (FLR) options. The final analysis resulted in fifteen potential restoration interventions, expanding the previously identified seven in UNIQUE study.

[1] Ministry of Environment, Forest and Climate Change (MEFCC). 2018. National Potential and Priority Maps for Tree-Based Landscape Restoration in Ethiopia (version 0.0): Technical Report. Addis Ababa: Ministry of Environment, Forest and Climate Change.

[2] Sophia Carodenuto, Gilbert Wathum, Laura Kiff, Till Pistorius, Timm Tennigkeit, 2015. Forest Landscape Restoration in Ethiopia, specific to Amhara National Regional State- Options for GIZ to support its implementation in the context of the Bonn Challenge 2.0. Methodology and results for Ethiopia.

2 Objectives of the Study

The project was carried with the following seven main objectives in mind:

1. Identify regional forest and land use sector **goals**
2. Identify main forest and land use sector **challenges** in Amhara region
3. Identify sector relevant **stakeholders** (institutions) to engage with in the region
4. Identify tree-based **FLR interventions** to address the identified challenges of the sector
5. Identify mapping **criteria** and **data** to map suitable areas for identified FLR interventions
6. **Map** spatial distribution of the identified FLR options
7. **Validate** draft maps and statistics from initial analysis

3 Methodology and Approach

The methodology and approach combined stakeholder engagement and expert analysis using Geospatial mapping tools. Amhara regional REDD+ (Reducing Emissions from Deforestation and Forest Degradation) team recruited 15 stakeholders from relevant institutions that were convened in Bahir Dar, Ethiopia from March 11-12, 2019 for an initial planning workshop. During the March planning workshop, stakeholders were engaged throughout the process to achieve objectives 1-5. The stakeholders were introduced into a national tree-based FLR mapping methodology. Following the half-day training, they were divided into groups to independently discuss thematic sessions described under the objectives section above. After each group session, the group representative reported back the results of their respective group exercises. All participants provided feedback, and necessary changes were made on consensus basis.

WRI experts took the criteria generated from the planning workshop and conducted the mapping work. ESRI GIS software modelling tools like the Model Builder were used for mapping the identified FLR options to achieve objective number six by translating the criteria and data into maps. Best available (accessible) local, national and global data (Table 2 & 3) were used as input to translate the criteria into maps. A validation workshop was held on August 22, 2019 in Bahir Dar city to validate the draft maps and statistics. The outputs for each objective are detailed in the following sections.

3.1 Identification of Forest and Land Use Sector Goals

The stakeholders were divided into three groups and tasked with identifying the main forest and land use sector goals in the Amhara region. Analysis results from all groups were further discussed and summarized (Box 1).

Box 1 | Regional Forest and Land Use Sectoral Goals/Targets

- Create employment
- Increase carbon sequestration
- Improve Ground Water Potential
- Improve livelihood and alleviate poverty
- Improve forest products values and value addition
- Reduce flooding and land slides
- Protect and Manage existing 950,000ha Natural. Forest and establish 2.3 Mha of plantations
- Promote ecotourism and other social and cultural values of forest landscapes (medicinal & traditional values)
- Increase Forest Cover by 1.2% annually to increase from current 13% to 19.1% at the end of GTP-II
- Determine Land use potential
- Reduce emissions from deforestation
- Reduce siltation and sedimentation
- Conserve and protect biodiversity
- Produce and distribute energy saving technologies
- Narrow the gap between supply and demand of forest products
- Substitute forest products import and generate income from exports of industrial wood products
- Reduce soil erosion by 70% by implementing Integrated Watershed Management and improve land productivity
- Conduct research to transform forest sector, and industrialize to increase the current 4% GDP contribution to 8% of Agriculture's (National) GDP

3.2 Identification of Forest and Land Use Sector Challenges

Working groups were then tasked with listing the most common biophysical challenges to achieving the identified forest and land use sectoral goals in the Amhara region (Box 2).

Box 2 | Biophysical Challenges towards Achieving Regional Forest and Land Use Sector Goals

- Habitat fragmentation/loss of biodiversity
- Loss of soil fertility
- Deforestation
- Forest degradation
- Landslides
- Air pollution (in urban areas)
- Water scarcity (in water bodies and soils)
- Overgrazing/free grazing
- Soil erosion
- Flooding
- Climate change impacts
- Siltation/sedimentation of water bodies

3.3 Identification of Relevant Stakeholders

During the third session, the working groups were tasked with identifying the list of organizations that are already involved in restoration directly or indirectly (Box 3).

Box 3 | Identified Relevant Stakeholders (Institutions) in the Region

- Bureau of Agriculture
- Abay Basin Development Authority
- Bureau of Water, Irrigation Energy/electricity
- ICRAF, Disaster Prevention and Preparedness
- Cooperatives Promotion agency
- Tourism Bureau
- Bureau of Women, Youth and Children affairs
- Bureau of Justice, law enforcement (Courts & Police)
- Science and Technology
- TVET (Technical and Vocational Education and Training), LULA Bureau
- Finance Institute (ACSI, Micro-Finance Institutions)
- Livestock Agency & Fishery Development Agency
- Wood Processing Factories
- Tana Sub-basin
- Bureau of Land administration & utilization
- EFCOA (REDD, FSDP, NFG/Norwegian Group
- AFE & Forest Seed Center
- Investment Promotion Agency
- NGOs (ORDA, GIZ, SLMP, PNSP, NABU, AGP)
- Institute of Biodiversity
- 13 Universities and Colleges
- ARARI (Research Centers), BEFRC
- Environment, Forest & Wildlife Protection and Development Agency

3.4 Identification of Tree-Based Restoration Interventions

During the planning workshop held in March 2019, the stakeholder groups came up with several generalized FLR interventions. Experts at the World Resources Institute (WRI) mapped the potential of each intervention by translating criteria developed during the workshop and existing secondary data into ArcGIS models. A workshop was conducted on August 22, 2019 in Bahir Dar, Amhara region to validate the results of the mapping exercise. Local stakeholders, most of whom were also participants in the planning workshop, helped to validate the draft products. Participants provided the project team with constructive feedback to incorporate into the draft maps. 13 final restoration options were selected after a two-stage iterative processes (Table 1). Both bamboo restoration and improved management of woodlands include two sub-types, thus total of 15 with the subtypes.

Table 1 | Identified FLR options

Maps (Value Column)	FLR Name	FLR CODE	Definitions	Decision-Making Process to Inform
1	Improved Management of Degraded Natural Forest	IMDNF	Introduce and/or improve the management aspects of existing forests and woodlands to guarantee optimal performance of its respective purposes and avoid deforestation.	REDD+ strategy and investment
2	Afforestation or Reforestation	AfR	Non-commercial planting/(assisted) natural regeneration to restore natural forest ecosystems	
3	Commercial Plantation Establishment	CPE	Largescale commercial planation development - not for the purpose of restoring natural ecosystems but to relieve pressure on natural ecosystems by producing commercial wood and wood products.	REDD+ strategy and investment
4	Agri-silvicultural Systems	AgSLV	All agroforestry types in croplands for a variety of purposes and in any arrangement (alley cropping, boundary trees, scattered trees, hedgerows, etc.).	Bureau of Agriculture strategy regarding agroforestry
5	Silvopastoral systems	Silvo	All agroforestry systems that integrate tree planting and management with livestock development (both in highlands and lowlands). The highland grasslands include areas that were once croplands or forestlands but are currently used for grazing, resulting in land degradation and productivity loss (marginal lands).	Burau of Agriculture strategy regarding increased livestock production and sustainable woodland management
6	Woodlot Establishment	WLE	Establishment of woodlots near agricultural lands. At times, due to extreme degradation and loss of crop productivity, parts of or all	REDD+ strategy and investment

Maps (Value Column)	FLR Name	FLR CODE	Definitions	Decision-Making Process to Inform
			areas used as crop fields may be eligible for woodlot establishment. Local government policies, local market value of wood products for certain species, and owners' consent will be integral to the decision-making process in these cases.	
7	Lowland Bamboo Development	LLBMB	Includes lowland bamboo areas with potential for bamboo restoration, excluding current bamboo forests mapped by INBAR 2016.	Amhara region's Lowland Bamboo Investment strategy
8	Highland Bamboo Development	HLBMB	Includes highland bamboo areas with potential for bamboo restoration, excluding the current bamboo forests mapped by INBAR 2016.	Amhara region's Highland Bamboo Investment strategy
9	Improved Management of Commiphora Woodlands	Myrrh	Improved management of Commiphora woodlands in eastern Amhara region, primarily for Myrrh development.	Myrrh and Gum Arabic in the Accacia-comiphora woodlands of Eastern Amhara lowlands
10	Improved Management of Combretum Woodlands	Incense	Improved management of Combretum woodlands in western Amhara region, primarily incense development.	Incense development in the Combretum woodlands of Western Amhara Lowlands
11	Religious Forest	RF	Religious (church) forests are critical seedbanks and sources of native biodiversity and are very common in the region. The focus of this intervention is to protect and manage these critical resources and refuges of native biodiversity.	Biodiversity conservation and development of seedbanks for native trees.
12	Riverine Forest	RIVN	This intervention refers to protecting and efficiently managing riverine forests along major rivers as unique ecosystems.	Reduce sedimentation and protect and re-establish unique riverine forest ecosystems.

Maps (Value Column)	FLR Name	FLR CODE	Definitions	Decision-Making Process to Inform
13	Wetland and Waterbody Buffer	WWB	There are few very critical waterbodies and wetland ecosystems in the region. Lake Tana, the source of Blue Nile and headwaters of the Grand Renaissance Dam, is an example of such critical resources. Tekeze Reservoir is another manmade lake that requires attention. This intervention aims to protect these critical waterbodies and restore and develop important wetland ecosystems.	Protect critical natural waterbodies like Lake Tana and reservoirs and dams by creating buffer around them. Restore and preserve viable wetland ecosystems
14	Afroalpine/Sub-Afroalpine Ecosystem Management	AASA	Afroalpine/Sub-Afroalpine sites are above tree line, and hence not eligible for tree-based FLR. However, the team suggested including the locations in the potential map because they are critical endemic biodiversity hotspots and have high hydrologic importance in the region. The main goal is given to preserve and improve their management, as deemed necessary.	Biodiversity conservation; Watershed protection
15	Biodiversity Priority Areas	BDPA	This intervention refers to all existing biodiversity priority areas, including Protected Areas, National Forest Priority Areas, and key biodiversity areas. This category is suggested for inclusion only to visualize on the region's potential map to facilitate coordination with the other FLR interventions. Appropriate BDPA interventions will be left to the current designated entities to consider and implement.	Include in restoration maps so that the existing designated agencies can develop sound management and synergy with restoration interventions in the vicinities of these biodiversity conservation areas.

3.5 Identification of Criteria and Data

After identifying potential interventions, criteria were developed to identify areas that are suitable for each restoration intervention. When the workshop criteria were incomplete or missing for a specific intervention, it was augmented or replaced by criteria used in UNIQUE's 2015 study and/or the national potential map of 2016. Table 2 presents the final set of criteria that was translated into the model builder and applied to the input data to produce the FLR potential maps.

Table 2 | Criteria for excluding ineligible areas from all tree-based FLR potential analysis

	Areas not suitable for any intervention	**Decision/Value**	**Justification**	**Data Source**
Exclusion from all Interventions	Sugarcane Plantations (SugarcanePlantations_ESC2016_UTM)	Excluded	Not suitable due to current designation restrictions	Ethiopian Sugar Corporation (ESC), 2016
	Industrial Parks (IndustrialParks_IPDC2016_UTM)			IPDC (Industrial Park Development Corporation), 2016.
	Hydropower Plants (Hydropower_MWIE2014)	Excluded including 0.5km buffer surrounding it		MoWIE (Ministry of Water, Irrigation and Electricity), 2015.
	Towns (CSA, 2007c)	Excluded including 0.5km buffer surrounding it	Current land use type is not eligible for restoration	CSA (Central Statistical Agency), 2007c. Cities and towns spatial data.
	Lakes (Lakes_MWIE2015)	Excluded		Ministry of Water Irrigation and Energy, 2015
	Reservoirs (Reservoirs_MWIE2015)			MoWIE (Ministry of Water, Irrigation and Electricity), 2015.
	Roads (ERA_2007)	Excluded including 15m buffer surrounding it		Ethiopian Road Authority, 2007
	Rivers layer (Rivers_VECEA2010)			Potential Natural Vegetation of Eastern Africa (VECEA), 2010

	INBAR National Bamboo map	Excluded	Mapped already by INBAR	International Network for Bamboo and Rattan (INBAR), 2016
	Plantation (AFE_Plantation_2016_UTM)	Excluded	Existing land designation	Amhara Forest Enterprise, 2016: Planation data

In addition to the above exclusion criteria for each intervention, multiple other criteria were applied to the input data to generate the final maps. Table 3 presents the final set of criteria for all identified FLR interventions that were translated into the model builder and applied to the input data to produce the FLR potential maps.

Table 3 | Final set of refined criteria

Interventions	Data	Decision	Explanation	Source
Improved Management of Degraded Natural Forest	Current land cover	Include Natural Forest	This refers to improved management of remaining degraded natural forest to avoid further deforestation while extracting goods and environmental services.	WLRC 2016; 30m
	Normalized Difference Vegetation Index (NDVI)	Included NDVI value <0.6	Management priority is for degraded forest. We used NDVI trends (2010 and 2018) to identify only degraded forest areas. To qualify as "degraded" the 2018, 16 daily mosaic NDVI value of the forest area should be less than that of 2010 (showing a declining trend); and 2018 NDVI should be less than 0.6 (workshop suggested criterium).	MOD13Q1.006 Terra NDVI, 16-Day Global; 250m[3]. Accessed using Google Earth Engine JavaScript API code[4].

[3] https://lpdaac.usgs.gov/products/mod13q1v006/

[4] https://code.earthengine.google.com/f03faea828d3d7cc1359cce72bd78331

Interventions	Data	Decision	Explanation	Source
	Productivity Dynamics (LPD)	Include LPD values: -1, -2, &, -3	In addition to NDVI trends (2010 to 2018), Land Degradation trend (LPD) from Trends.Earth[5] was used to separate degraded forests from intact forests. According to Trends.Earth, the values -1, -2, and -3 represent stressed, moderate decline, and decline status, respectively. These three categories were used together with NDVI trends to exclude intact forest and focus on only degraded natural forest from the current land use map.	Trends.Earth. Conservation International, 2018. Available online at: http://trends.earth
Adapted from UNIQUE 2015 study, national mapping criteria, and workshop inputs				
Afforestation / Reforestation	Natural potential vegetation	Include: • Acacia-Commiphora woodland and bushland • Acacia wooded grassland of the Rift Valley • Combretum-Terminalia woodland and wooded grassland • Dry evergreen Afromontane forest and grassland complex • Moist evergreen Afromontane forest • Transitional rainforest	Areas where trees could grow based on the national potential vegetation atlas, field expertise from national botanical experts, and suitability modeling.	Van Breugel et al. 2015; National, 90m.

[5] http://trends.earth/docs/en/pdfs/Trends.Earth_Tutorial04_Using_Custom_Productivity.pdf

Interventions	Data	Decision	Explanation	Source
	Current land cover	Exclude Forest, Settlement, wetlands, Waterbodies	Currently forest and/or legally or ecologically not feasible for AfR intervention	WLRC 2016; 30m
	Slope	Include croplands and grasslands in slope > 60%	Rural lands where the slope is greater than 60% will be restricted from farming and free grazing; they will be used for the development of trees, perennial plants, and forage production (FDRE 2005).	Derived from SRTM v4.1, 2014
	Productivity Dynamics (LPD)	Refine to focus on degraded lands and land areas with declining productivity	Land Degradation trends (LPD) from Trends.Earth[6] were used to focus on degraded lands. According to Trends.Earth, the values -1, -2, and -3 represent stressed, moderate decline, and decline status, respectively. These three categories were used to exclude productive lands.	Trends.Earth. Conservation International, 2018. Available online at: http://trends.earth
	Tree crown cover	Exclude all areas where tree crown cover is >20%	Areas with more than 20% tree crown cover are considered forests, according to Ethiopia's forest definition. and are excluded from afforestation/reforestation potential.	Hansen et al. 2014
	Rainfall	Exclude < 400mm	In areas with less than 400 mm annual rainfall, survival and growth of planted trees are highly restricted.	NMA, 2000; 1 km
	Elevation	Exclude > 3,750 m above sea level	Land above 3,750 m altitude is Afro-alpine, which is not suitable to tree planting.	Derived from SRTM v4.1, 2014
Adapted from UNIQUE 2015 study, national criteria for restoration of secondary forests, and ANRS Experts from the March 2019 workshop				

[6] http://trends.earth/docs/en/pdfs/Trends.Earth_Tutorial04_Using_Custom_Productivity.pdf

Interventions	Data	Decision	Explanation	Source
Commercial Plantation Establishment	Current land cover	Includes bareland, degraded cropland, and bush/shrubland	Other land use classes are not eligible for commercial plantation either because they are not ecologically viable for profitable business or are designated as protected areas to protect natural ecosystems.	WLRC 2016; 30m
				Tree Cover, 30m
	Land Productivity dynamics (LPD) layer	Include unproductive croplands: LPD value -2 & -3	Land Degradation decline trends (LPD) from Trends.Earth site were used to separate degraded croplands. According to Trends.Earth, the values -1, -2, and -3 represents stressed, moderate decline, and decline status, respectively. The last two categories were used together to extract degraded croplands from the current land use map.	Trends.Earth. Conservation International, 2018. Available online at: http://trends.earth
			Croplands that fall within these two categories are also potential candidates for plantations as this might be a more profitable and sustainable option.	
	Market accessibility	Exclude areas farther than 20 kms from roads[7]	Markets need to be easily accessed to transport and sell wood products.	ERA 2007.
	Areas legally or socially protected	Exclude religious forests	Some religious forests might be too small to be classified as forest, but nonetheless should be preserved.	Not readily available
	Minimum size	Exclude areas < 10 ha	It is not economically profitable to invest in commercial plantations smaller than this threshold.	Final geoprocessing output

[7] At the validation workshop, the team discussed and suggested to update the single 10km buffer threshold criterion into multiple ring buffers with additional 20km. The argument was dependent on C/B analysis of the project (timber, fuelwood, poles and posts, etc.); some projects might remain profitable if established even farther away (e.g., industrial wood plantations vs pols and posts).

Interventions	Data	Decision	Explanation	Source
	Slope	Include 30% - 60%	This upper threshold is meant to avoid the risks of landslides during skidding and harvesting (national criteria); the lower threshold is to avoid competition with cropland (ANRS Experts)	Derived from SRTM v4.1, 2014
	Altitude	Include 1,500m - 3,200m	Even though trees can survive outside this range, this is the range suggested by workshop participants for commercial plantations to remain profitable because performance and yield matters here, not only survival.	
	Average Annual Rainfall	Exclude < 1,000 mm	The workshop suggestion for commercial plantation is 1000mm even though 800mm/year is the minimum average annual rainfall allowing a yield of 15m^3/ha/year for Grevillea and 25 m^3/ha/year for eucalyptus.	Hijmans et al. 2005.
National criteria for industrial and on-industrial wood plantations and ANRS experts at the March 2019 workshop				
Agri-silvicultural Systems	Current land cover	Include cropland	Agri-silvicultural (multipurpose tree intercropping) takes place on croplands	WLRC 2016; 30m
	Agricultural practices	Exclude mechanized farming	These agricultural lands were not deemed compatible with agroforestry practices.	No readily available data for mechanized farming and rice fields.
		Exclude rice fields		
		Exclude large-scale sugarcane plantations		For large-scale sugarcane plantations: ESC 2016.

Interventions	Data	Decision	Explanation	Source
	Slope	Exclude> 60 %	Rural lands whose slope is greater than 60% will not be used for farming and free grazing; they will be used for development of trees, perennial plants, and forage production (FDRE 2005). Therefore, if croplands currently exist above this slope, they will be included in the AfR FLR option and are excluded from agroforestry.	Derived from SRTM v4.1, 2014
	Tree cover	Include areas with less than 50 trees/ha or tree cover <20 %	In the absence of data on tree density, percent tree cover is used. Agroforestry systems with greater than 30% tree cover are considered already well-stocked (while ICRAF proposes that "agroforestry" be defined by tree cover greater than 10% on farms; it also recognizes the potential to improve existing agroforestry system with 10–30% tree cover [Zomer et al. 2014]). For Ethiopian context, greater than 20% tree cover is defined as forest. Hence, we used 20% instead of 30%.	Hansen et al. 2014
	Rainfall	Exclude < 400 mm	Below 400 mm annual rainfall, survival and growth of planted trees are highly restricted.	NMA, 2000; 1km
	Elevation	Exclude > 3,750 m above sea level	Land above 3,750 m altitude is Afro-alpine and should not be planted with trees.	Derived from SRTM v4.1, 2014
National criteria and ANRS Experts, March 2019 workshop				
Improved Management of Woodlands	Potential Natural Vegetation Atlas of Ethiopia (PNV)	Include: • Acacia-Commiphora woodland and bushland • Combretum-Terminalia woodland and wooded grassland	These are the two woodland classes in the eastern and western lowlands of Amhara region containing Commiphora (Myrrh) and Combretum (Incense), respectively. The management of these woodlands was proposed by the validation workshop.	Van Breugel et al. 2015

Interventions	Data	Decision	Explanation	Source
	Current land cover	Include Woodlands and shrublands/bushlands	Within the above two PNV classes, shrublands/bushlands is the most dominant category, followed by the woodland class, according to the current WLRC landcover map. Hence, both categories are included.	WLRC 2016; 30m
	Elevation	Exclude >3750m	This is tree line limit.	Derived from SRTM v4.1, 2014
Adapted using UNIQUE 2015 study, National criteria and validation workshop input				
Silvopastoral Systems	Current land cover	Include grassland	Silvopastoral systems are located in grasslands	WLRC 2016; 30m
	Tree cover	Exclude area with tree cover > 20%	Pastoral land with 20% or more tree cover is considered an already well-stocked silvopastoral systems (ICRAF proposes "agroforestry" to be defined by tree cover greater than 10% on farms [Zomer et al. 2014], but experts proposed also promoting the improvement of existing silvopastoral systems with 10–20% tree cover).	Hansen et al. 2014, 30m
	Invasive species	Include areas with invasive tree species	While invasive species might show a canopy cover of more than 20%, the species are not desirable. These areas need to have the invasive species eradicated before increasing their tree cover with desirable species.	No readily available data.

Interventions	Data	Decision	Explanation	Source
	Protection of natural ecosystems	Exclude natural grassland ecosystems: the grassland overlaps on both the Natural Potential Vegetation Atlas and current WLRC Land use map	These natural grassland ecosystems must be protected, and trees shouldn't be promoted there.	WLRC 2016 ; 30m & Van Breugel et al. 2015 ; 90m
	Relic forest	Exclude religious/relic forests		Data available but not accessible yet.
	Average annual rainfall	Exclude areas ≤ 250 mm	There is little potential for trees in areas with less than 250 mm average annual rainfall.	Hijmans et al. 2005.
	Productivity Dynamics (LPD) & NDVI Decline	Include degraded lands	Combined with NDVI decline (2010 to 2018); Land degradation decline trends (LPD) from Trends.Earth were used to separate degraded grasslands. According to this dataset the values -1, -2, and -3 represent land productivity status as stressed, moderate decline, and declining, respectively. These three categories were used together with NDVI to refine and focus only on degraded grasslands on the current land use map.	Trends.Earth. Conservation International, 2018. Available online at: http://trends.earth
	Elevation	Exclude area >3750m	Land above 3,750 m altitude is Afro-alpine and should not to be planted with trees.	Derived from SRTM v4.1, 2014
Adapted from workshop and national criteria for agro-silvopastoral systems				
Woodlot Establishment	Current land cover	Include bare land within 2km from agricultural lands	Bare lands contiguous with agricultural lands are considered available and suitable for woodlots. Woodlots are found within agricultural lands or close to homesteads for ease of management	WLRC 2016; 30m

Interventions	Data	Decision	Explanation	Source
	Landcover & Productivity Dynamics (LPD) Layer	Include unproductive agricultural land (intersection b/n cropland and productivity layer)	Woodlots are to be promoted on degraded, unproductive, and formerly cultivated lands (i.e., lands that are categorized as -2 or -3 on the LPD layer).	Trends.Earth. Conservation International, 2018. Available online at: http://trends.earth
	Rainfall	Exclude < 400 mm	In areas with less than 400 mm of annual rainfall, survival and growth of planted trees are highly restricted.	NMA, 2000; 1 km
	Elevation	Exclude > 3,750 m above sea level	Land above 3,750 m altitude is Afro-alpine and should not be planted with trees.	Derived from SRTM v4.1, 2014
	Area	Include <10ha	Areas larger than this threshold are assumed to be commercial plantations.	Final geoprocessing output map
UNIQUE 2015 study and criteria developed by ANRS experts at March 2019 workshop				
Bamboo Restoration	National bamboo potential map	Include the Amhara portion of the national bamboo potential map	Since there is no new regional data to improve the national bamboo map, the national one was taken as is and clipped to view the Amhara region.	National Potential and Priority Maps for Tree-Based Landscape Restoration in Ethiopia, 2018
Religious Forest	Digitized church forest	Include	Religious (church) forests are very common in Amhara and are critical seedbanks for native trees and resources for biodiversity conservations[8].	Digitized from Google Earth Engine
Manually digitized church forests on Google Earth				

[8] https://www.nationalgeographic.com/environment/2019/01/ethiopian-church-forest-conservation-biodiversity/#close

Interventions	Data	Decision	Explanation	Source
Riverine Forest	Current land use map	Include forest, waterbodies, and wetlands	Riverine forests are characterized as dominating floodplains and resistant to waterlogging conditions. Given lack of existing data on riverine forests, we extracted three landcover classes that will most likely be suitable as habitats for riverine forests. Then, the rivers layer was used, with 200m buffer added around it (100 m each side). This buffer was used as a mask to extract areas from the previous three classes. Because the rivers layer and the terrain were showing some misalignment, and it is common for rivers to meander in floodplains, we chose wider buffer and slope threshold criteria instead of the 30m buffer that was suggested during the validation workshop.	WLRC 2016; 30m
	Rivers	Include areas with 200m of major Rivers	Will be used to make the 200 m buffer.	VECEA 2010
	Slope %	Include only slope < 10% (<5 Degrees)	Riverine forests dominate floodplains. Therefore, slope cutoff may be included as an additional criterion when data is absent on the exact habitats of the riverine forest.	Derived from SRTM v4.1, 2014
Validation workshop suggested criteria adapted to available data				
Wetlands and Waterbody Buffer	Current Land use	Include waterbodies and wetlands	Eligible land use categories.	WLRC 2016; 30m
	Rivers	Include the areas overlapping the "Shoreline class" of the rivers layer (VECEA2010 Rivers). Use extract by attribute tool to select the	Participants at the validation workshop including these areas. Shoreline areas extracted from the rivers layer were used as one of the potential inputs.	VECEA 2010

Interventions	Data	Decision	Explanation	Source
		shoreline class as follows: "a-Type = %shoreline%		
	Buffer	Create a buffer of 1km around the combined output of the previous two inputs.	For both wetlands and waterbodies, tree-based restoration is relevant only as an outside buffer. Therefore, a 1km buffer was established as an eligible zone for appropriate waterbody and wetland FLR interventions to enhance the protection of these ecosystems by reducing erosion and siltation from the surrounding areas among others.	Output from preceding GIS Analysis steps
Validation workshop suggested criteria adapted to available data				
Afroalpine-Subalpine	Potential Natural Vegetation Atlas of Ethiopia	Include Afroalpine & Montane Ericaceae belt	These are the most relevant classes to satisfy the intent expressed at the validation workshop; the two classes also align well with the 3000m elevation limit.	Van Breugel et al. 2015; 90m
	Protected Areas	Exclude Biodiversity Priority sites	Within the Afroalpine/Sub-Afroalpine region, there are parks and conservation areas that should be excluded from this analysis. Those biodiversity priority areas will instead be included in the biodiversity priority restoration category since they may have stricter legal restrictions.	EWCA 2015
Validation workshop suggested criteria adapted to available data				
Biodiversity Priority Areas	Protected Area	Include all Protected Areas (PAs) layers (contains parks, reserves, community conservation areas, wildlife sanctuaries)	These are the biodiversity hotspot areas designated by government, which face interference and encroachment challenges. Creating buffer zones around them where appropriate FLR interventions are implemented would help to minimize the anthropogenic impacts on protected areas.	EWCA 2012

Interventions	Data	Decision	Explanation	Source
	KBAs	All areas included	Refers to Key Biodiversity Areas are biodiversity hotspots areas with priority focus for conservation and management, as identified by Conservation International in 2016.	Key Biodiversity Areas 2015, Bird Life International
	NFPAs	All areas included	Most National Forest Priority Areas in Ethiopia are important areas in which to restore natural forest ecosystems.	NFPAs 2015, WDPA Regional office
	Buffer	Create buffer of 1km around the PAs	Use output from previous step and make a buffer zone to consider developing with PAs authorities. This would minimize the level of encroachment to these critical biodiversity hotspot areas by creating alternative resources in the vicinity to meet the community needs.	The output from preceding step
Validation workshop suggested criteria adapted to available data				

3.6 Mapping Spatial Distribution

Each of the identified FLR options were mapped by translating the identified criteria and input data into maps employing ESRI ArcGIS model builder tools (Appendix 2). The output is the maps and hectarage statistics for each of those FLR options presented under "Results" section. To spare excess technical jargon, we did not include the complete list of all models and explanations in this main report. The models are submitted with the GIS database.

3.7 Validation of the Preliminary Results

A one-day validation workshop was conducted in Bahir Dar in August 2019 to evaluate the preliminary results of the mapping. Result was presents which shows the mapping methodology and output results that include the spatial distribution of the FLR options and their hectarage. There were suggestions made to split some original FLR options and add new few non-tree-based restoration interventions. Accordingly, the mapping task was rerun to reproduce the maps were which incorporated the stakeholders' feedback from validation workshop. The final analysis resulted in 15 FLR options presented under "Results" section below.

Photo credit: Tesfay Woldemariam, WRI

4 Results

4.1 Summary Statistics and Spatial Distribution of Identified FLR Options

WHEN READING (TABLE 4) AND THE FOLLOWING SECTIONS, PLEASE NOTE THE MEANING OF "EXCLUSIVE" VS "OVERLAPPING" IN THIS CONTEXT AND THE IMPLICATIONS. EXCLUSIVE MEANS THOSE AREAS ARE SOLELY SUITABLE (HAS POTENTIAL) FOR THE SPECIFIED FLR INTERVENTION (NO COMPETITION). OVERLAPPING AREAS MEAN THAT THOSE LOCATIONS ARE SUITABLE (HAS POTENTIAL) FOR MORE THAN ONE FLR OPTION AND EITHER OF THE THOSE OVERLAPPING FLR OPTIONS CAN BE IMPLEMENTED THERE. THIS IN TURN IMPLIES THAT TWO OR MORE FLR OPTIONS ARE COMPETING FOR THE SAME LOCATION. HENCE, IT WOULD REQUIRE RANKING AND PRIORITIZATION FOR FINAL DECISION USING ADDITIONAL CRITERIA, BOTH BIOPHYSICAL AND/OR NON-BIOPHYSICAL DATA SUCH AS LOCAL COMMUNITY PRIORITIES ON THOSE SPECIFIC LOCATIONS.

The total potential for all identified interventions, including non-tree-based restoration interventions in Amhara region is about 13.58Mha, which is 87% of the region's area (Table 4). About 7.15Mha of this total is exclusively available area (no overlap), split among the 15 respective FLR options, whereas the remaining 6.43Mha has two or more overlaps. There are two intervention types which are of non-tree-based category included upon the stakeholders' recommendation; namely, the "Biodiversity Priority Areas (BDPA)" and "Afroalpine/Sub-Afroalpine (AASA)" area. The two constitute about 3.00Mha and 0.60Mha respectively. These two are not ideal for tree-based restoration interventions because the former has legal restriction and the latter has ecological limitations due to the tree line elevation threshold (situated above 3,750m). The experts at the workshop suggested to include them for purpose of spatial referencing in the maps in relation to the identified tree-based FLR interventions in the vicinity so that planning is coordinated. However, this does not mean appropriate restoration and improved management interventions to naturally regenerate native vegetation and overall ecological functions are forbidden in these two categories.

Hence, the final total biophysical potential for all tree-based FLR options is about 10.00Mha or 64% of the region's area. Table 4 presents the details on how the total potential area of 13.58Mha is split among the 15 identified FLR options identified (including the non-tree-based ones) and the overlap scenarios.

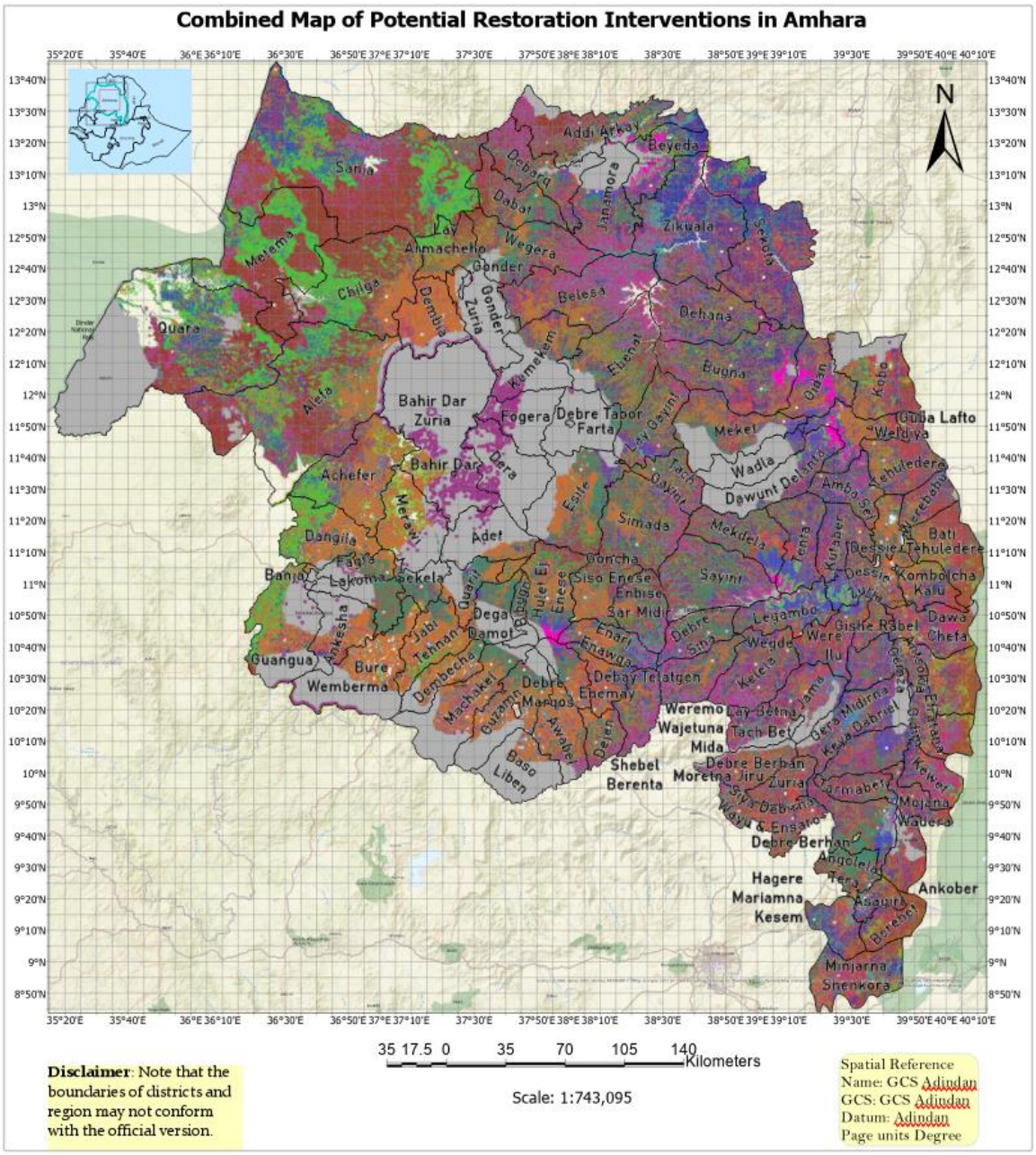
Table 4 | Area statistics of identified interventions

GIS (map) Code	FLR Code & Name	Exclusive (ha)	Overlap (ha)	Total (exclusive + overlap) (ha)	% share of total FLR	% Share of region area
1	IMDNF (Improved Management of Degraded Natural Forest)	106,117	78,318	184,435	1.36%	1.18
2	AfR (Afforestation Reforestation)	871,032	3,637,386	4,508,418	33.19%	28.97
3	CPE (Commercial Plantation)	35,568	158,694	194,262	1.43%	1.25
4	AgSLV (Agri-silvicultural Systems)	1,549,939	2,820,076	4,370,015	32.17%	28.08
5	SILVO (Silvopastoral Systems)	2,986	333,904	336,890	2.48%	2.16
6	WLE (Woodlot establishment)	219,530	497,702	717,232	5.28%	4.61
7	LLBMB (Lowland Bamboo)	308,703	2,509,682	2,818,385	20.75%	18.11
8	HLBMB (Highland Bamboo)	441,742	1,518,092	1,959,834	14.43%	12.59
9	Myrrh (Commiphora Woodlands)	55,329	360,560	415,889	3.06%	2.67
10	Incense (Combretum Woodlands)	563,485	1,591,118	2,154,603	15.86%	13.84
11	RF (Religious Forest Management)	28	168	196	0.00%	0.00
12	Riverine (Riverine Forest)	1,763	5,156	6,919	0.05%	0.04
13	WWBF (Wetland and Waterbody buffer)	93,461	413,699	507,160	3.73%	3.26
14	AASA (Afro-Sub Afroalpine ecosystems)	115,942	479,112	595,054	4.38%	3.82
15	BDPA (Biodiversity Priority Areas)	2,786,785	218,580	3,005,365	22.13%	19.31
Total		7,152,410	6,430,716	13,583,126		
%		46%	41%	87%		
Region Area				15,564,811		

KEY: *The sum of overlapping FLR cells and Total FLR area cannot be added as in table 4. It overestimated due to multiple suitability. Explore the tables included in appendices 5 and 6 for clarity.*

The "Combined Tree-based FLR Potential Map" (Figure 1) presents the spatial distribution of all combinations of restoration potentials on a pixel by pixel basis. The total number of combinations is 207.9 The map is complex at regional level, but together with information contained in its attribute table, it is an invaluable decision support tool for regional, even site level planning.

Figure 1 | Map of Combined Tree-based Restoration Potential



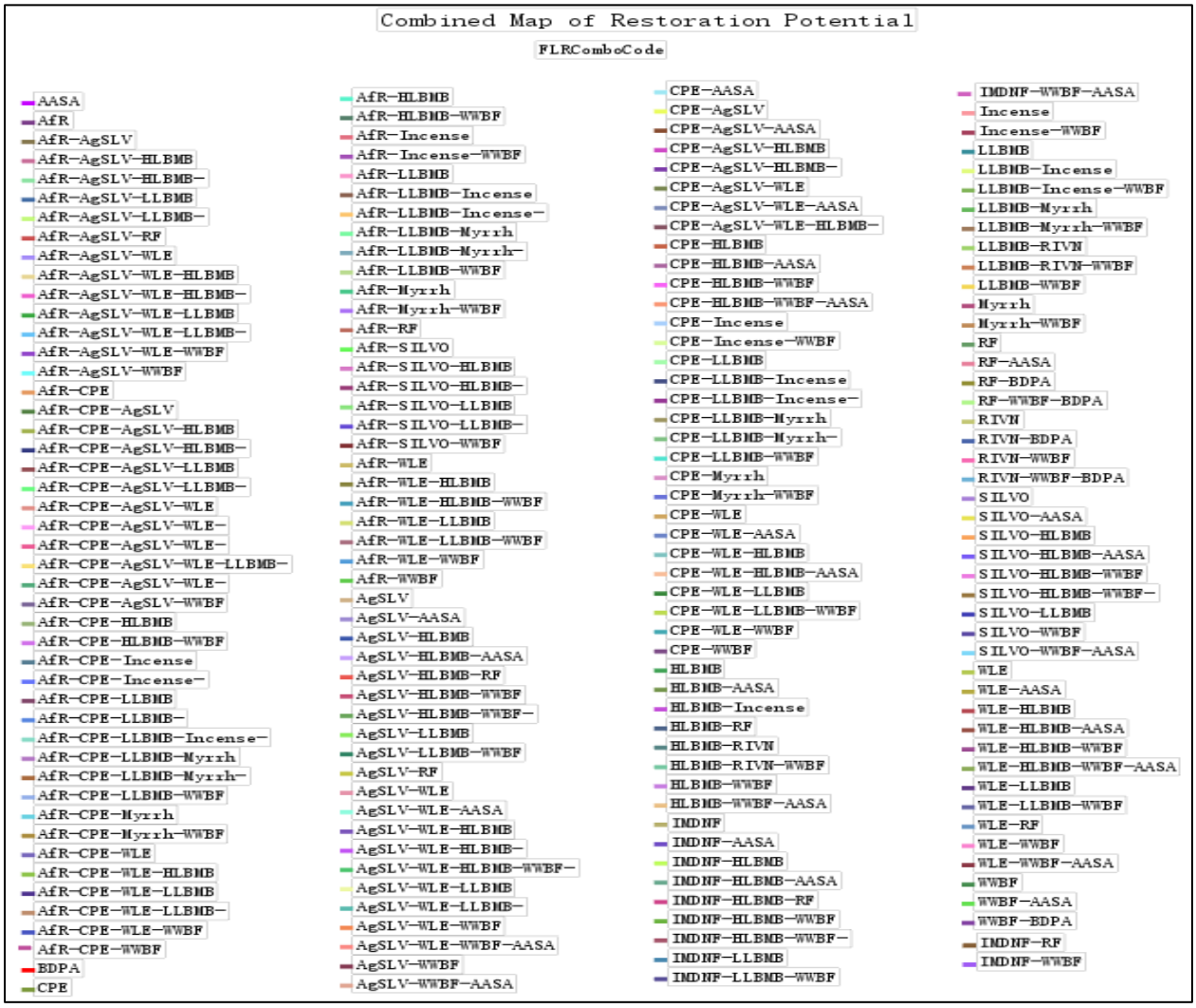
Note: The administrative boundaries used in this map are not authoritative.

[9] Explore the map using the provided legend and acronyms for the combined interventions code.

Box 4 | FLR Options Code[10]

1 = **IMDNF** = Improved Management of Degraded Natural Forest
2 = **AfR** = Afforestation Reforestation
3 = **CPE** = Commercial Plantation
4 = **AgSLV** = Agri-silvicultural
5 = **SILVO** = Silvopastoral
6 = **WLE** = Woodlot establishment
7 = **LLBMB** = Lowland Bamboo
8 = **HLBMB** = Highland Bamboo
9 = **Myrrh** = Commiphora Woodlands
10 = **Incense** = Combretum Woodlands
11 = **RF**= Religious Forest
12 = **Riverine** = Riverine Forest
13 = **AASA** = Afro-Sub Afroalpine ecosystems

Box 5 | Legend of the combined FLR map



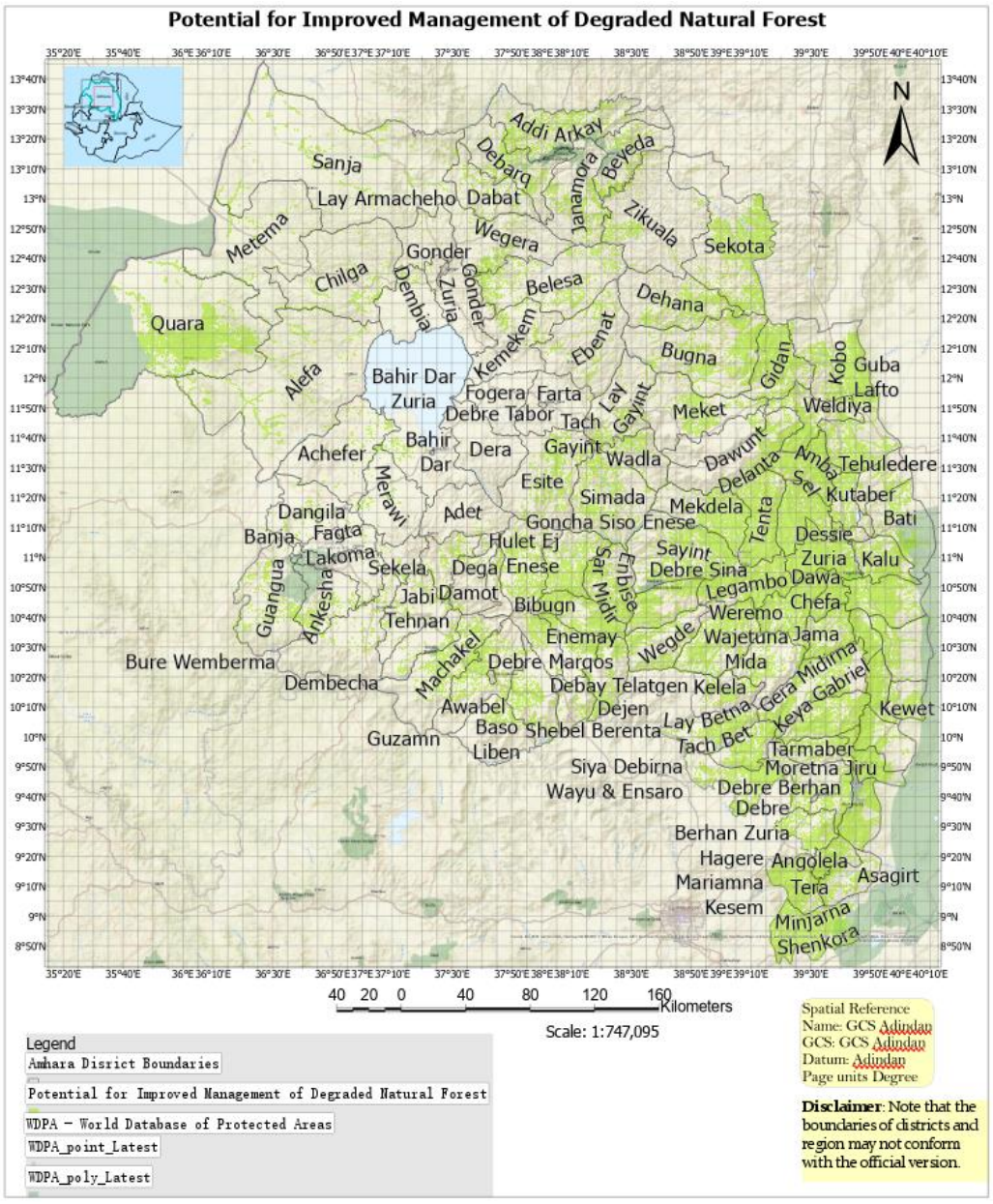
[10] Legend: the GIS ID of the interventions, acronyms, and full name. Use it with the legend below.

The FLR combination codes (Box 4) in conjunction with the legend (Box 5) should enable you to explore the map. The corresponding color scheme (Box 5) is random symbology of each the 207 possible combinations. More than single FLR codes separated by "-" represent the number of overlapping FLRs. All 15 identified interventions are represented. To reduce the number of combinations and simplify the readability of the map, district by district maps (Appendix 4) were generated an available both in GIS database and as pdf printouts for all districts of Amhara.

4.2 Potential for Improved Management of Degraded Natural Forest (IMDNF)

About 0.18Mha of Amhara region has potential for Improved Management of Degraded Natural Forest. 0.11Mha of this total potential area is exclusively available for Improved Management of Degraded Natural Forest FLR option while the remaining 0.08Mh overlap with one or more of the other FLR options (Table 4). The following map depicts the spatial distribution of biophysical potential for IMDNF FLR option across Amhara region.

Figure 2 | Map of Potential for Improved Management of Degraded Natural Forest Intervention

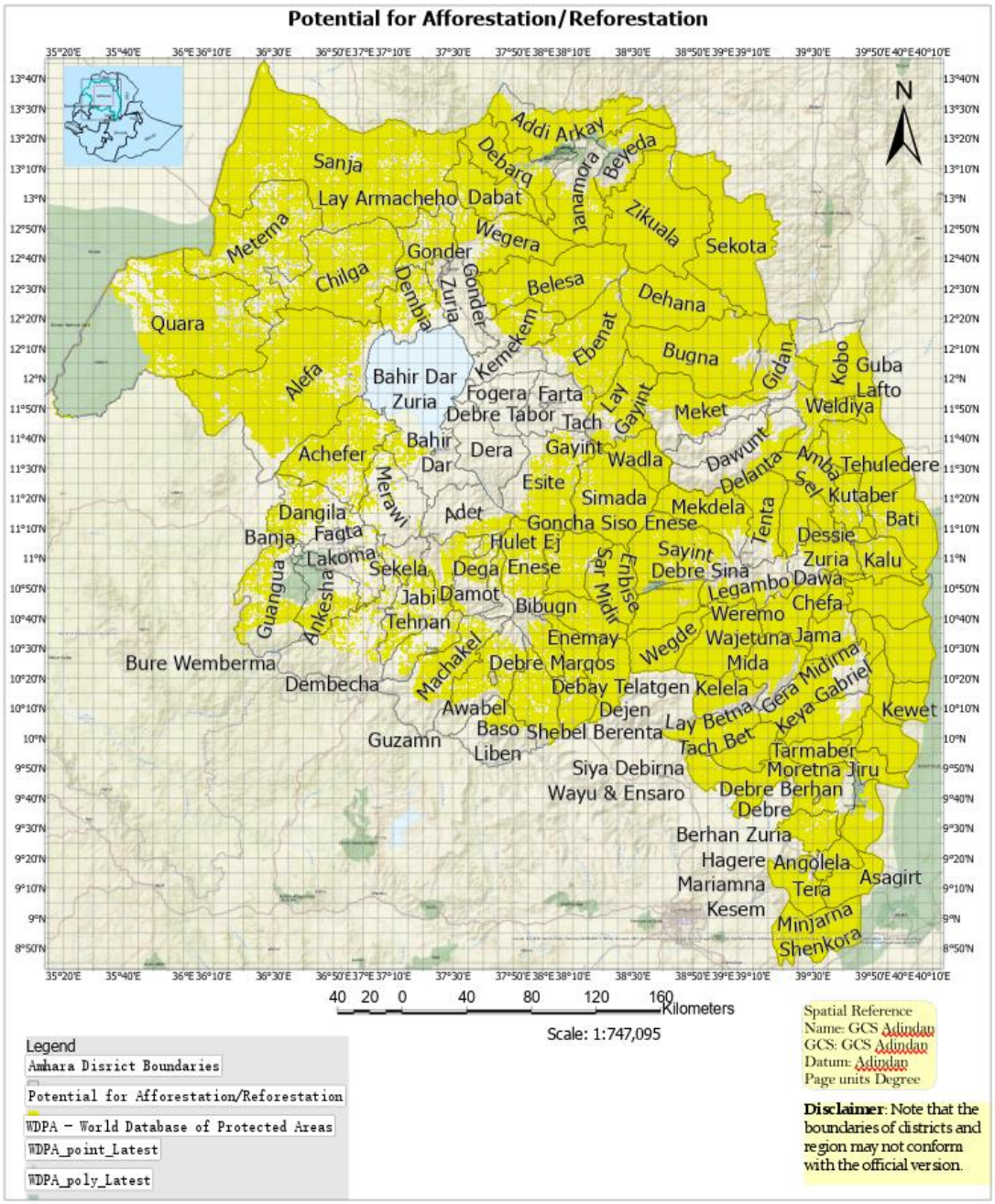


Note: The administrative boundaries used in this map are not authoritative.

4.3 Potential for Afforestation/Reforestation of Degraded Lands (AfR)

About 4.51Mha of Amhara region has potential for Afforestation/Reforestation. 0.87Mha of this potential area is exclusively available for AfR intervention, while the remaining 3.64Mha overlap with one or more of other FLR options. The following map depicts the spatial distribution of biophysical potential for AfR across Amhara region.

Figure 3 | Map of Potential for Afforestation/Reforestation Intervention

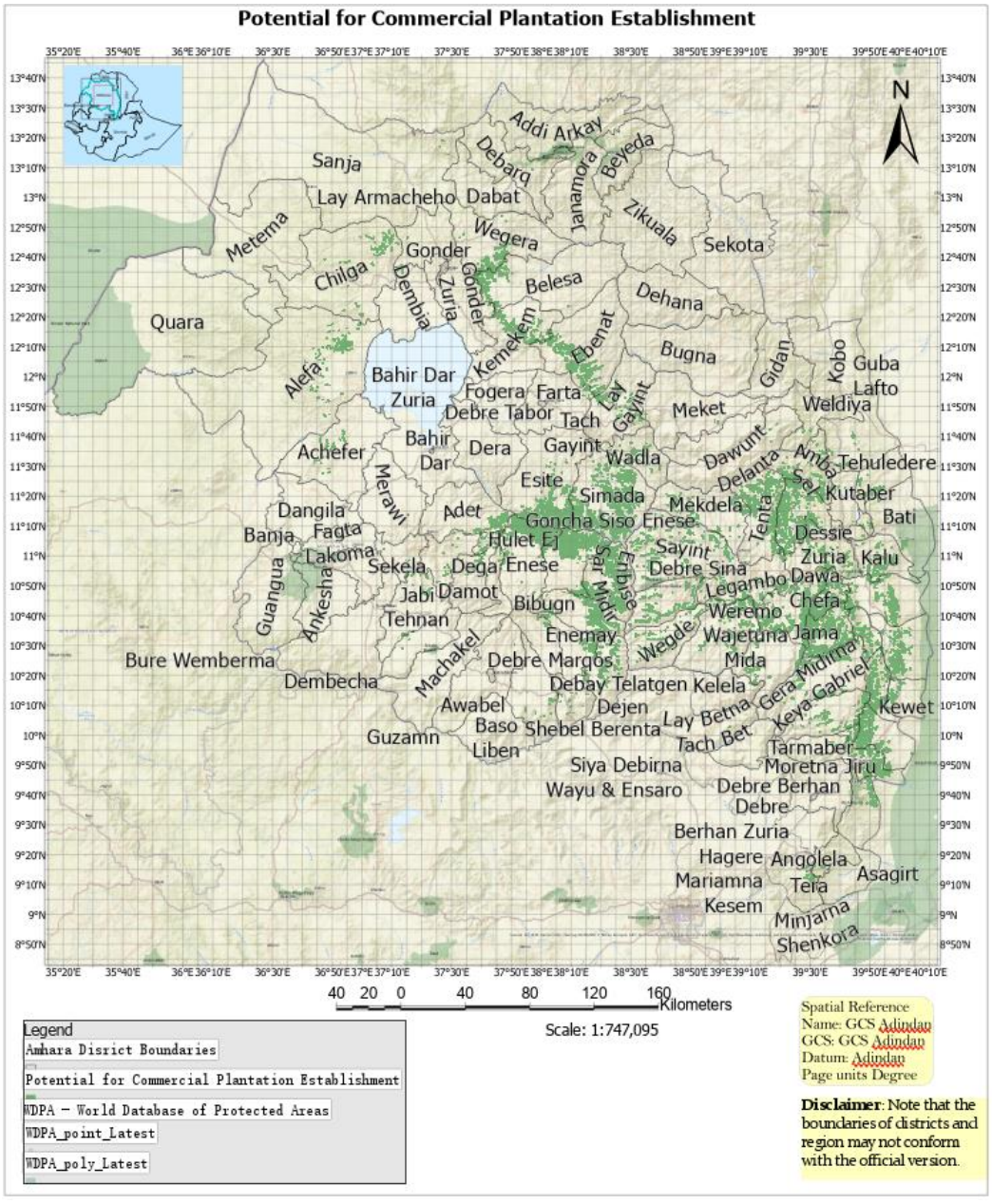


Note: The administrative boundaries used in this map are not authoritative.

4.4 Potential for Commercial Plantation Establishment (CPE)

About 0.19Mha of Amhara region has potential for Commercial Plantation Establishment. 0.04Mha of this total potential area is exclusively available for CPE option while the remaining 0.16Mha overlaps with one or more FLR intervention. The following map depicts the spatial distribution of biophysically potential areas for Commercial Plantation Establishment across the entire Amhara region.

Figure 4 | Map of Potential for Commercial Plantation Establishment Intervention

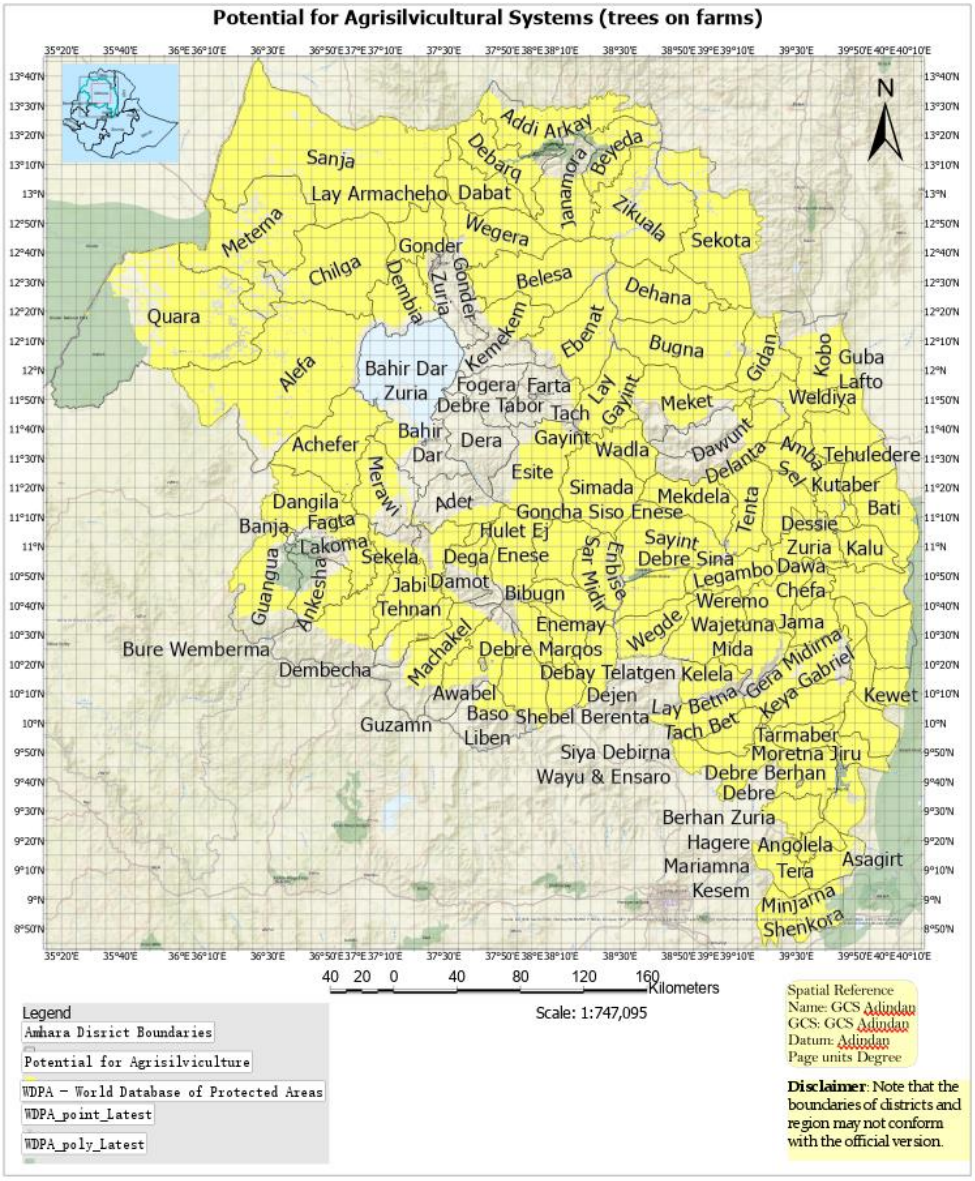


Note: The administrative boundaries used in this map are not authoritative.

4.5 Potential for Agri-Silvicultural Systems (AgSLV)

About 4.37Mha of Amhara region has potential for Agri-silvicultural FLR intervention. 1.55Mha of the total potential area is exclusively available for Agri-silvicultural FLR intervention, while the remaining 2.82Mha has overlaps with one or more FLR option. The following map depicts the spatial distribution of biophysically potential areas for Agri-silvicultural Systems across the entire Amhara region.

Figure 5 | Map of Potential for Agri-silvicultural Systems Intervention

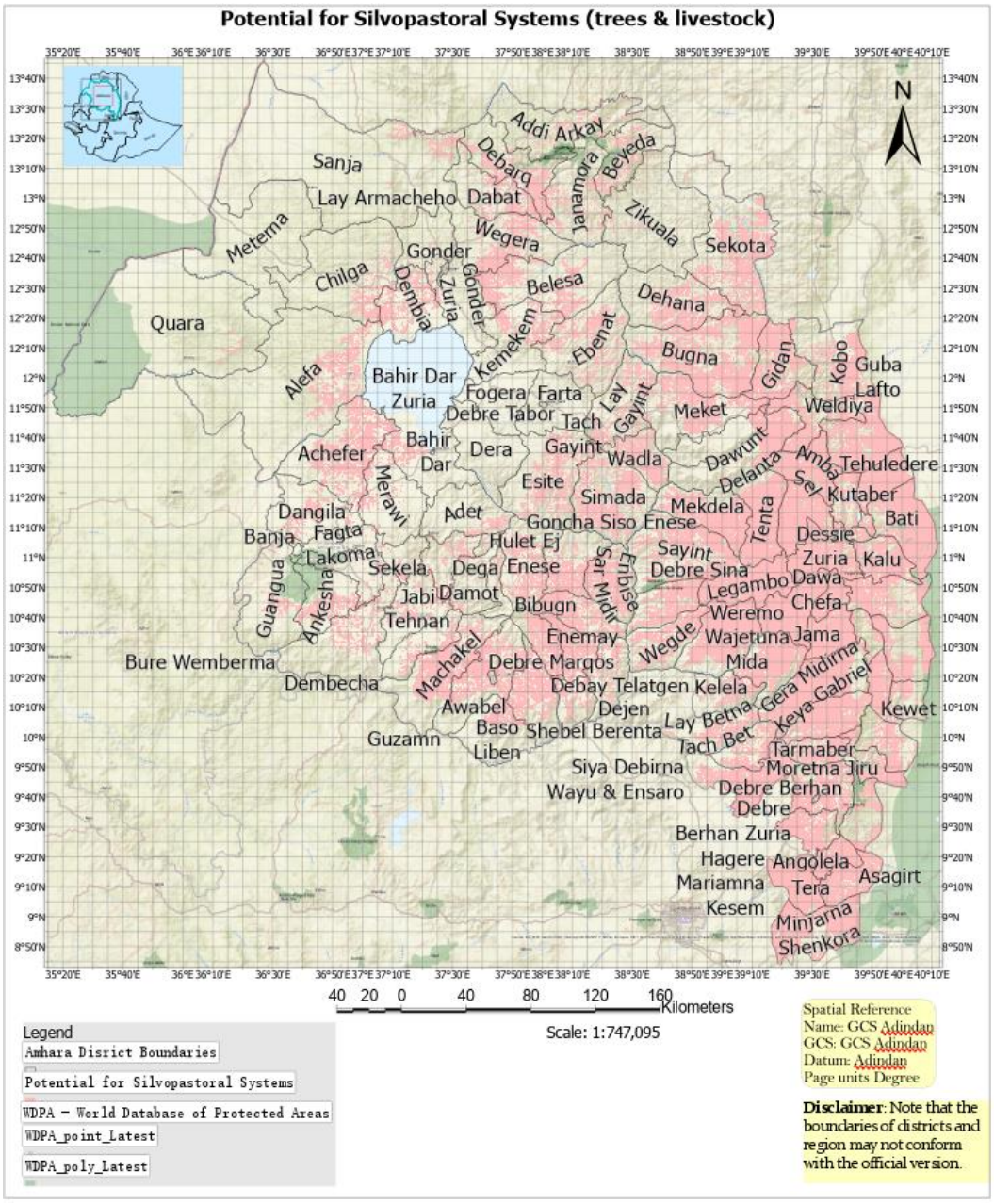


Note: The administrative boundaries used in this map are not authoritative.

4.6 Potential for Silvopastoral Systems (SILVO)

About 0.34Mha of Amhara region has potential for Silvopastoral FLR options. About 2,980ha of this total potential area is exclusively available for Silvopastoral FLR intervention while the remaining 0.33Mha overlap with one or more other FLR option. The following map depicts the spatial distribution of biophysically potential areas for Silvopastoral FLR across the entire Amhara region.

Figure 6 | Map of Potential for Silvopastoral Systems Intervention

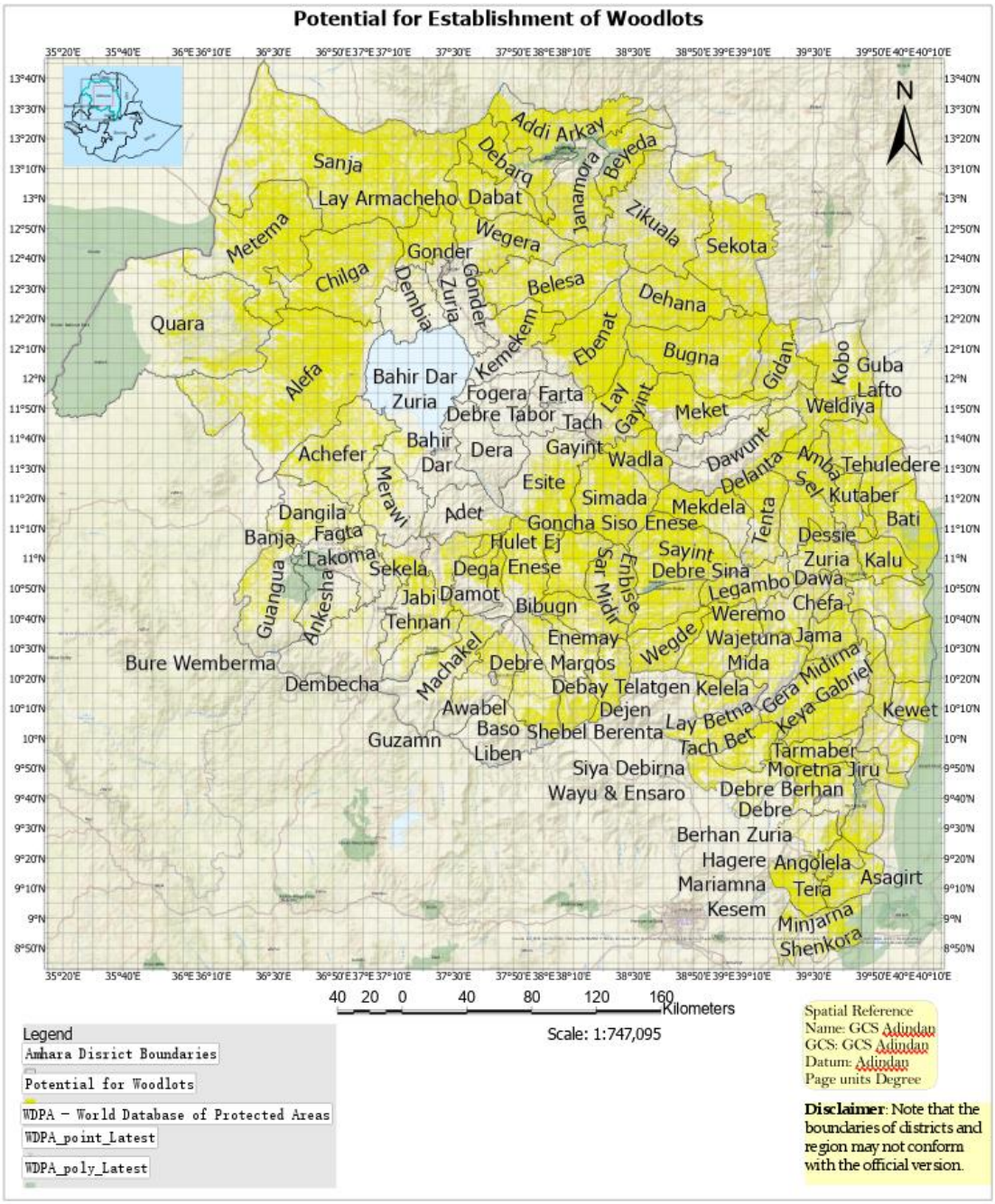


Note: The administrative boundaries used in this map are not authoritative.

4.7 Potential for Woodlot Establishment (WLE)

About 0.72Mha of Amhara region has potential for Woodlot Establishment FLR option. About 0.22Mha of this total potential area is exclusively available for WLE, while the remaining 0.50Mha overlap with one or more FLR option. The following map depicts the spatial distribution of biophysically potential areas for WLE across the entire Amhara region.

Figure 7 | Map of Potential for Woodlot Establishment Intervention

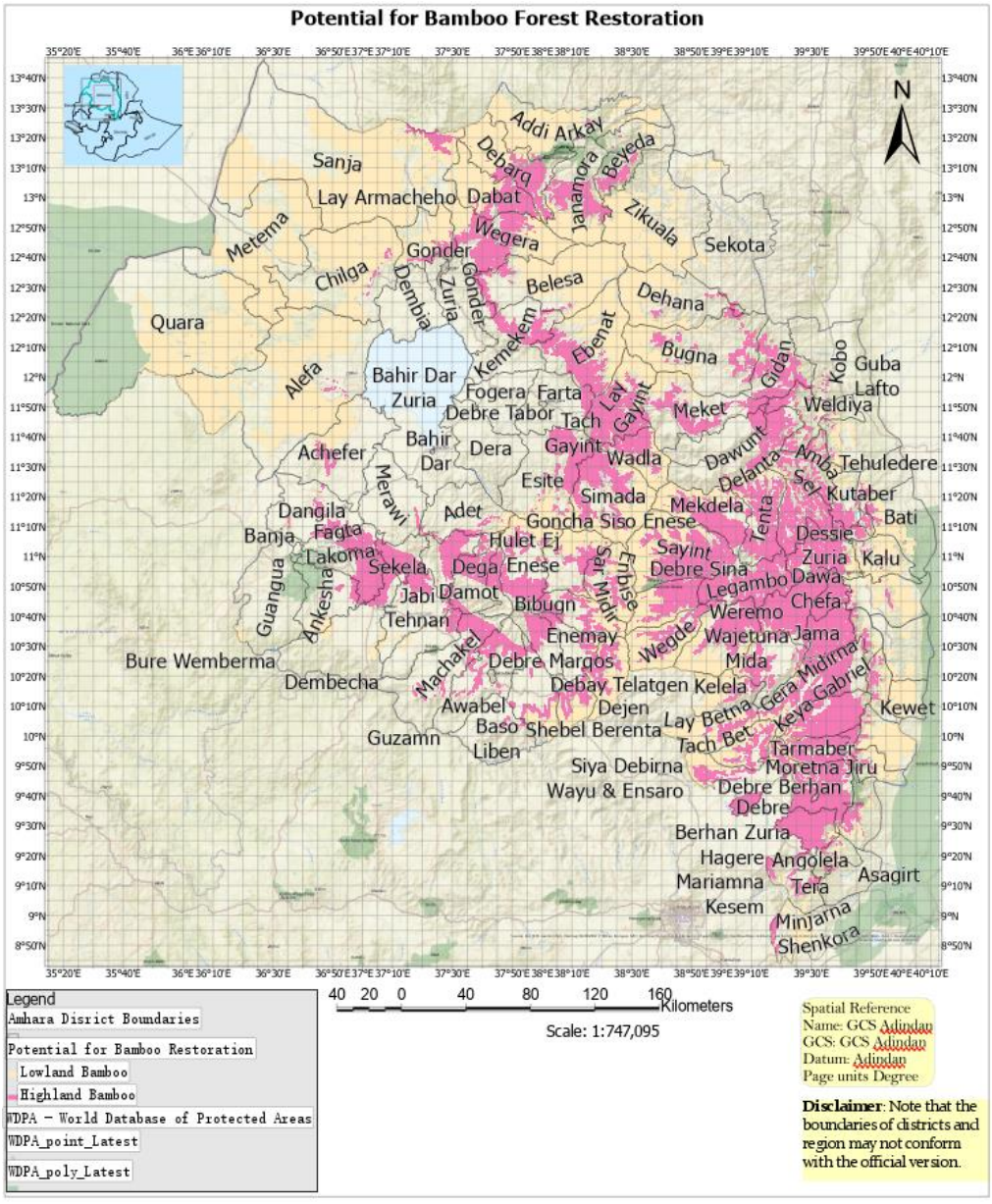


Note: The administrative boundaries used in this map are not authoritative.

4.8 Potential for Bamboo Restoration (LLBMB/HLBMB)

About 4.78Mha of Amhara region has the potential for Bamboo restoration FLR option. This total is split between Lowland Bamboo and Highland Bamboo FLR options. The LLBMB potential is 2.82Mha, while the HLBMB potential is 1.96Mha. Of this total potential, 0.31Mha and 0.44Mha are exclusively available for LLBMB and HLBMB respectively. The remaining 2.51Mha of LLBMB and 1.52Mha of HLBMB overlap with one or more other FLR options. The following map presents the spatial distribution of the biophysically suitable land area for both Bamboo types.

Figure 8 | Map of Potential for Bamboo Restoration

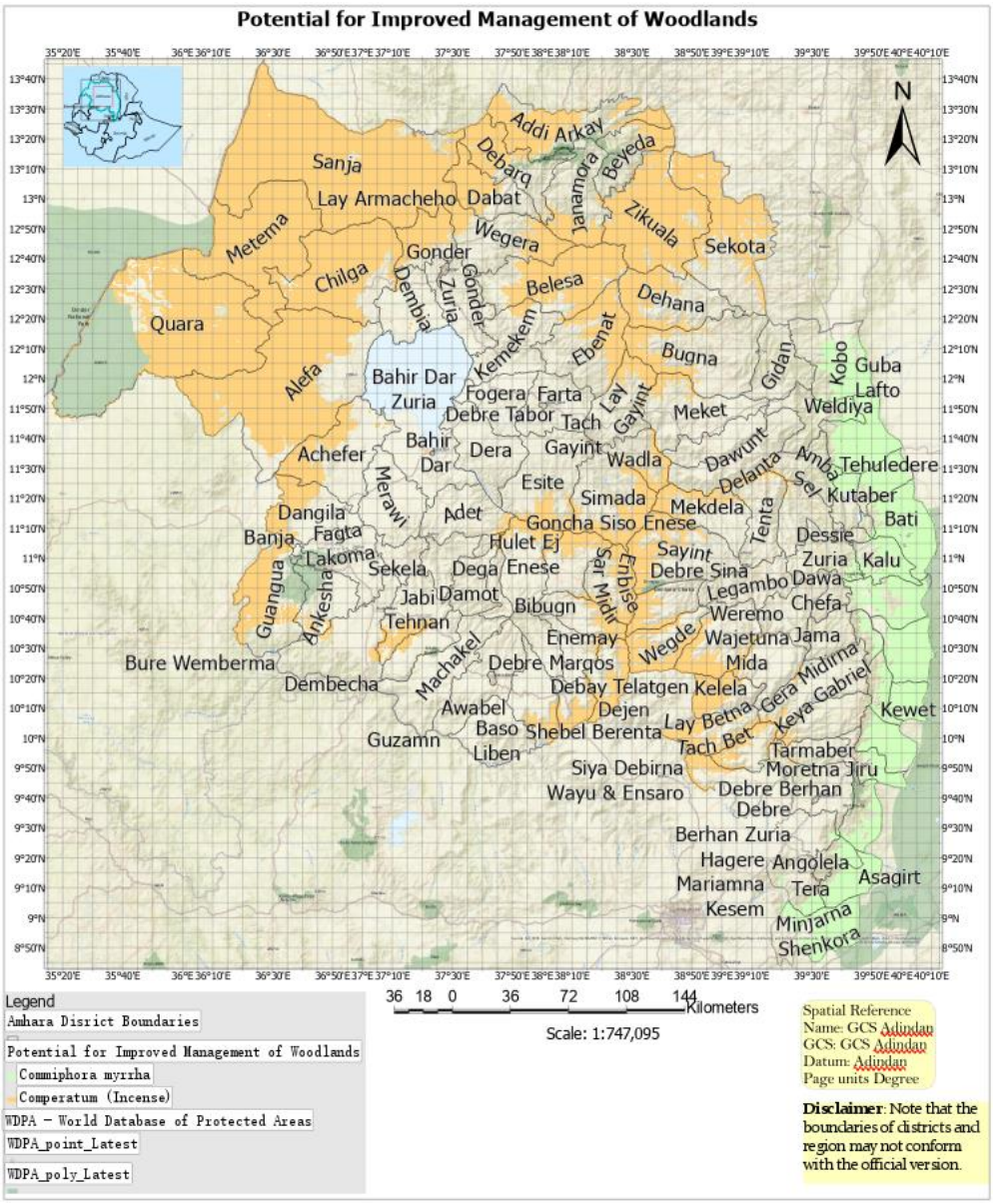


Note: The administrative boundaries used in this map are not authoritative.

4.9 Potential for Improved Management of Woodlands (Myrrh & Incense)

About 0.47Mha in the eastern part of Amhara region has potential for Commiphora Woodland restoration (MYRRH) and about 2.15Mha in the western part of the region has potential for Combretum Woodland restoration (INCENSE). Respectively 0.06Mha of MYRRH and 0.56Mha of INCENSE are exclusively available for respective FLR Option. The remaining area overlaps with one or more other FLR options (Table 4). The following map presents the spatial distribution of the biophysically suitable land area for both Myrrh and Incense intervention.

Figure 9 | Map of Potential for Woodland Restoration (Myrrha & Incense)

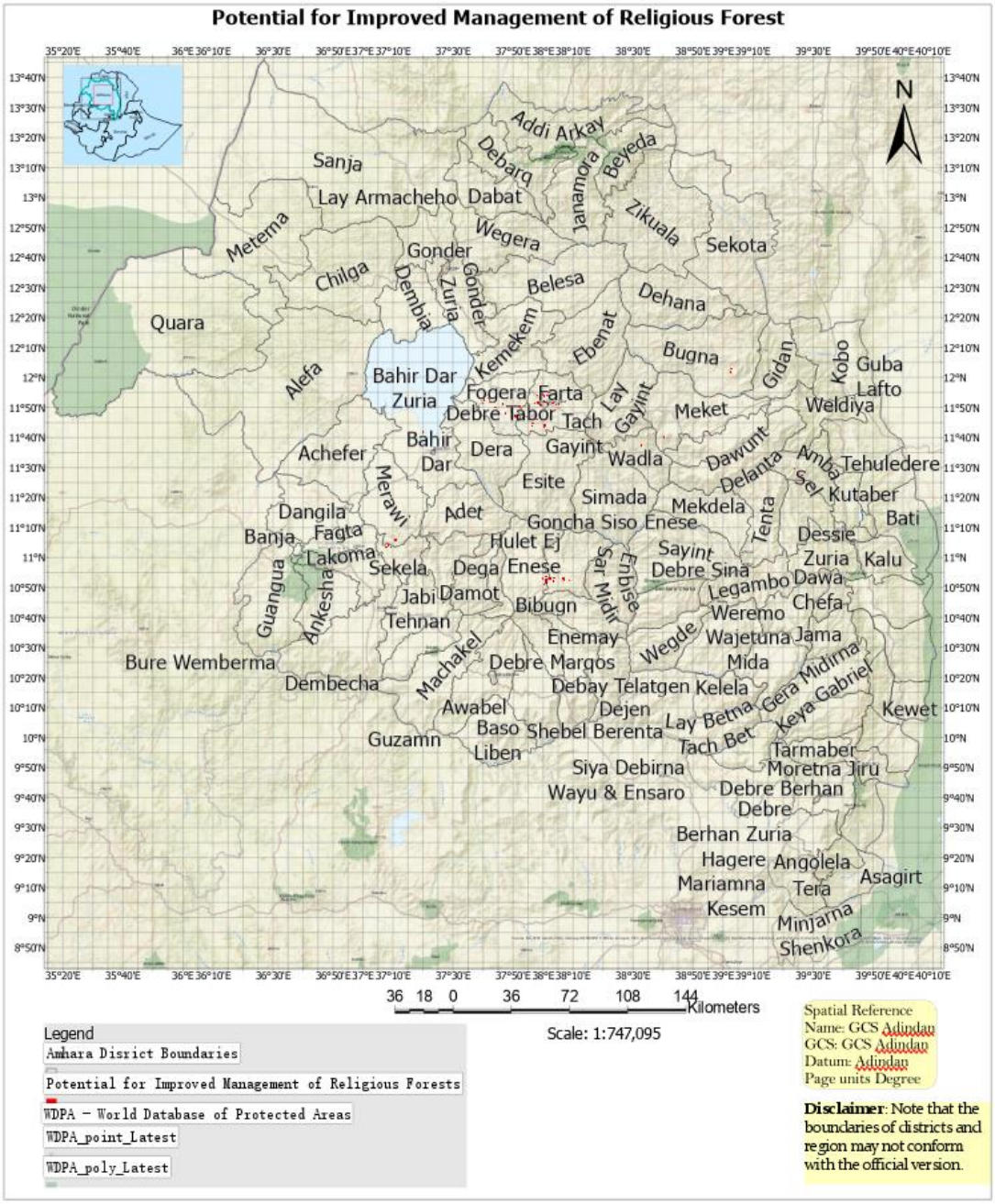


Note: The administrative boundaries used in this map are not authoritative.

4.10 Potential for Religious Forest Management (RF)

The total area of 96 religious (Church) forests manually digitized is about 169ha. The map does not contain all the potential existing religious forests in the region (data was not accessible). Once completed, the map will assist regional planning of all religious forest resource, primarily in church compounds.

Figure 10 | Map of Potential for Religious Forest Management

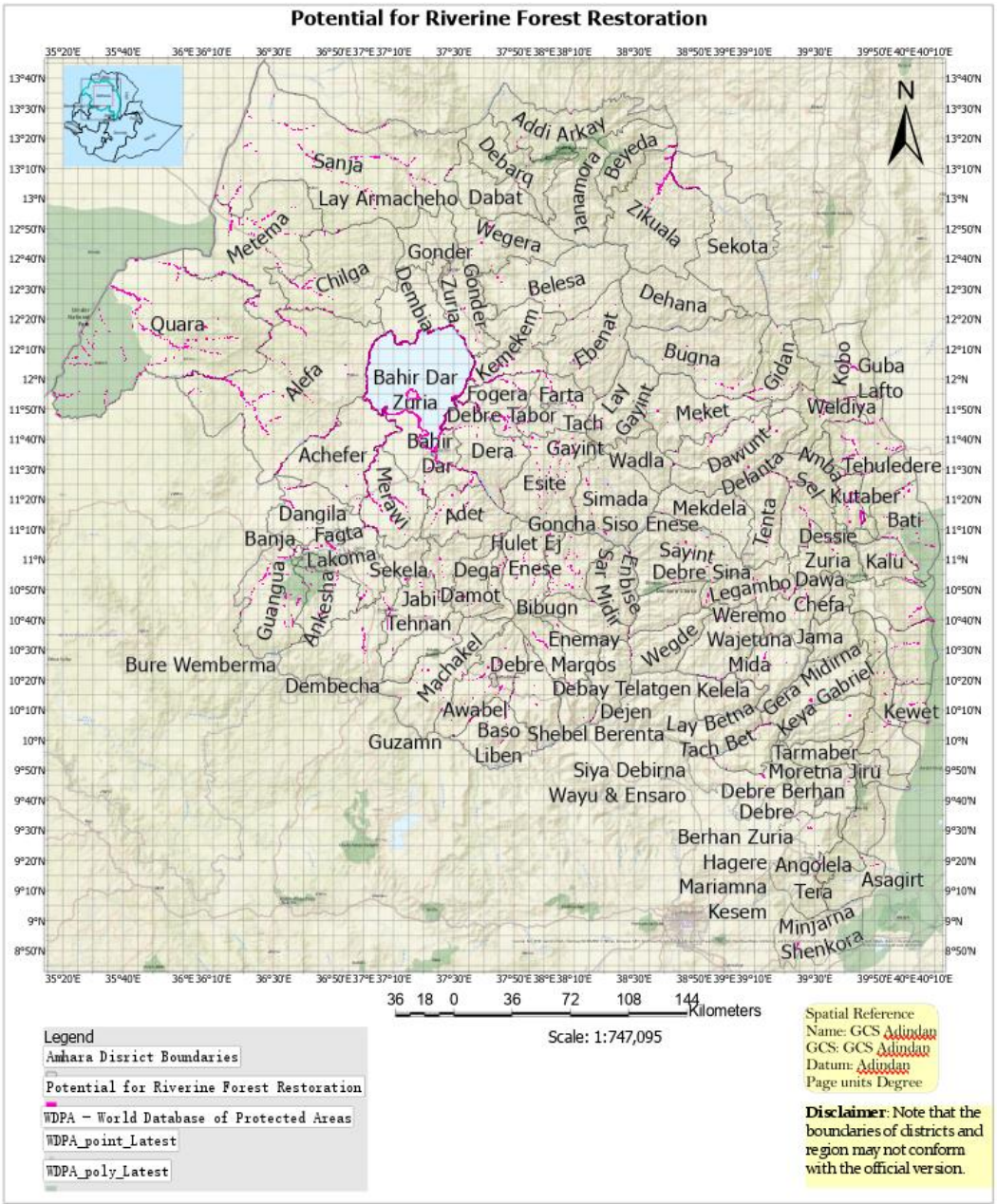


Note: The administrative boundaries used in this map are not authoritative.

4.11 Potential for Riverine Forest Restoration (RIVN)

About 7,000ha of the region is suitable for riverine forest restoration. Of the total potential area, 1,760ha is exclusively available for this intervention while the remaining overlaps with other FLR options (Table 4). The following map depicts the spatial distribution of the RIVN potential areas.

Figure 11 | Map of Potential for Riverine Forest Restoration

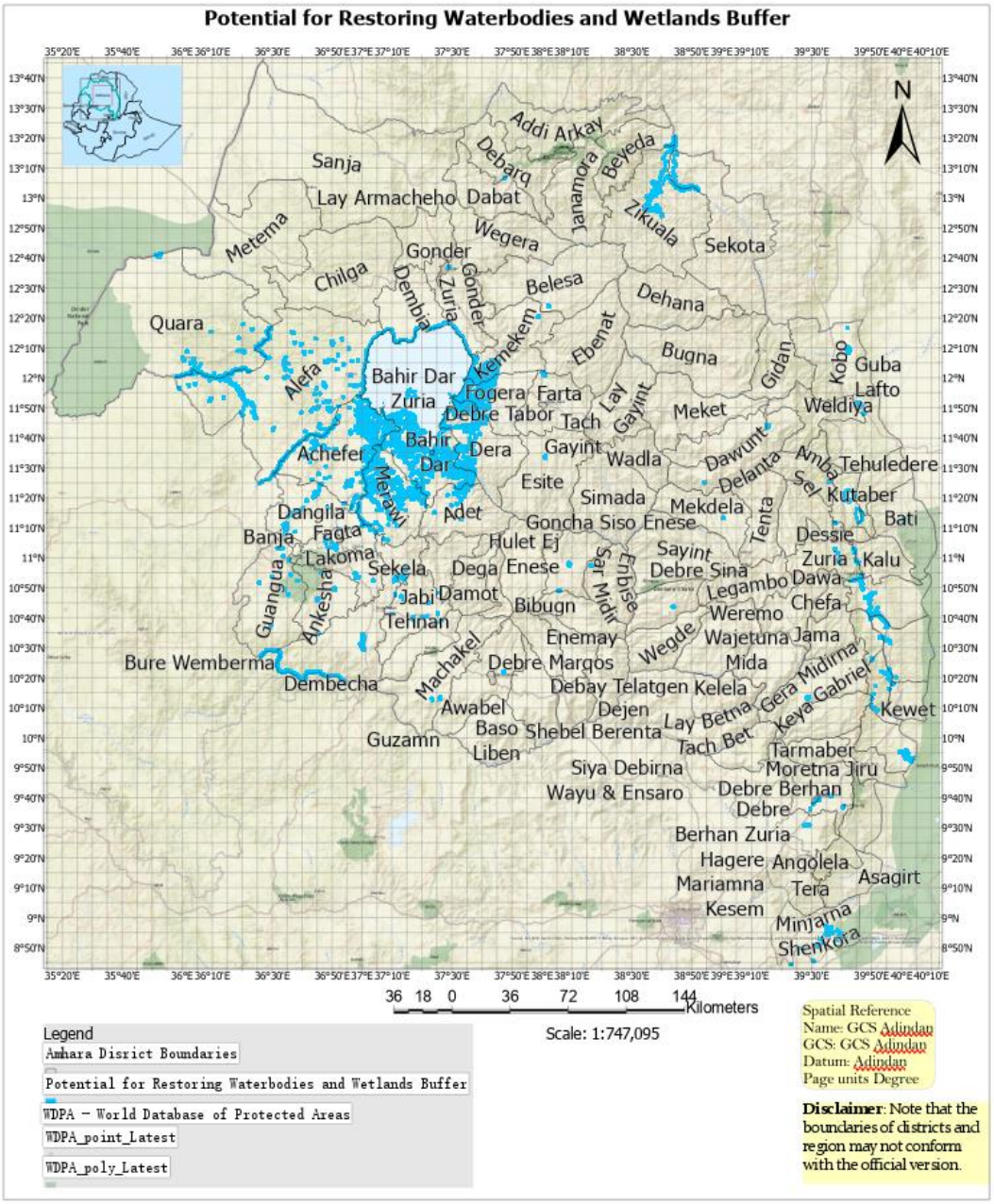


Note: The administrative boundaries used in this map are not authoritative.

4.12 Potential for Wetland and Waterbody Protection Buffer Development (WWBF)

About 0.51Mha of the region is has potential for wetland and waterbody protection buffer restoration FLR. Of the total potential area, 0.09Mha is exclusively available for WWBF intervention, while the remaining overlaps with one or more other FLR options (Table 4). The following map depicts the spatial distribution of WWBF FLR option.

Figure 12 | Map of Potential for Wetland and Waterbody Buffer Restoration

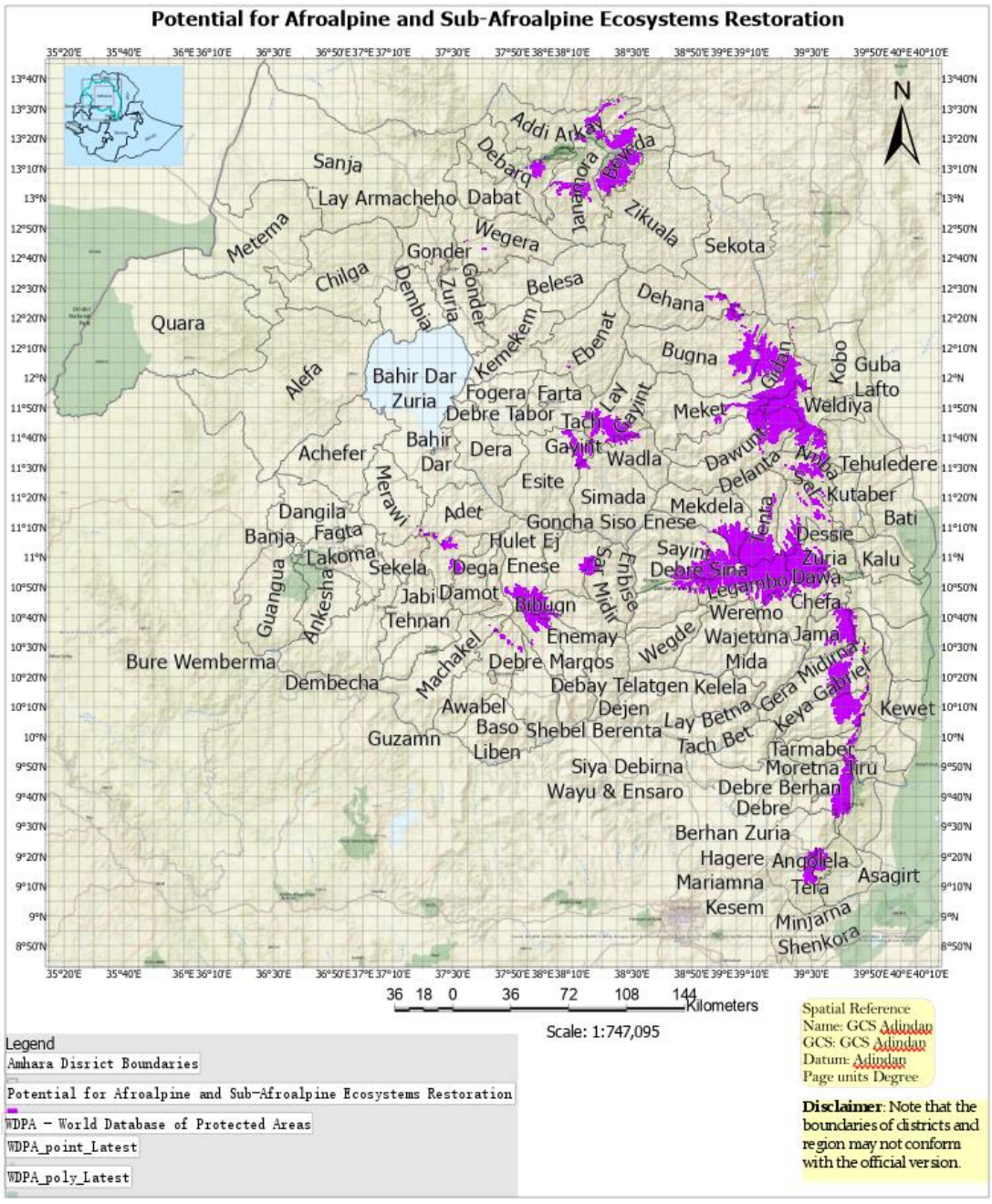


Note: The administrative boundaries used in this map are not authoritative.

4.13 Potential for Afroalpine and Sub-Afroalpine Ecosystem Restoration (AASA)

About 0.60Mha of the region has potential for Afroalpine/Sub-Afroalpine restoration (Table 4). This map will assist the regional planning by identifying Afroalpine and Sub-Afroalpine ecosystems in the region.

Figure 13 | Map of Potential for Afroalpine/Sub-Afroalpine Ecosystem Restoration

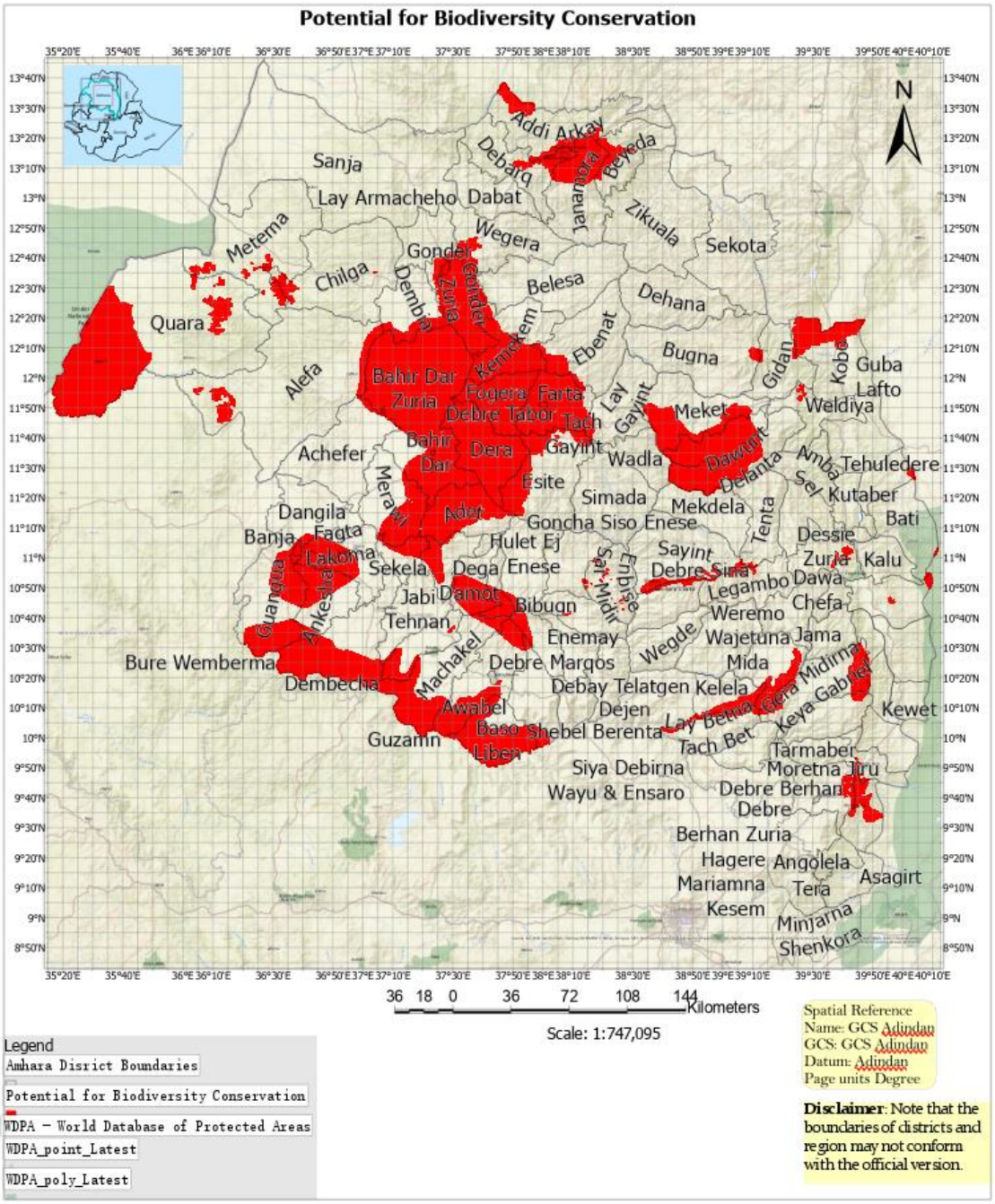


Note: The administrative boundaries used in this map are not authoritative.

4.14 Potential for Conservation of Biodiversity Priority Areas (BPDA)

About 3.01Mha of the region is designated as biodiversity priority areas. BPDAs are restricted from tree planting but natural regeneration might be enhanced by improved management of them. This map shows the spatial distribution of BPDA areas.

Figure 14 | Map of Potential for Biodiversity Priority Areas



Note: The administrative boundaries used in this map are not authoritative.

5 Conclusion

The desired outcome of the study is to enable the region to better plan, assess, and implement various tree-based FLR interventions. Through both distribution mapping and hectarage statistics, this study shows the potential for various forest and landscape restoration interventions in Amhara region. Note the figures are solely based on biophysical feasibility analysis based on the available criteria and data. About 41 % of the total available potential has one or more overlaps (Table 4). Both scenarios entail further refining as well as ranking to prioritize among the overlapping FLR options. This should be considered with additional data (biophysical and non-biophysical) during action plan development. Field verification of the maps was not an integral part of this project and we strongly recommend it to be carried out before implementation. A logical next step would therefore, to do a similar exercise focused on non-biophysical analysis that takes into consideration the regional and local policies and regulatory aspects, community priorities, and enabling environment.

Finally, it is critical to develop and action plans for respective FLR intervention that assesses the cost-benefit analyses of each intervention type. Action plans should evaluate also the enabling environment, the overall Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, and the mode of implementation (private, community, government led.). We hope these maps once verified will be important decision support tools in the sector including the potential to fundraise with, mobilize resources, develop projects, and implement restoration on the ground.

6 Acknowledgements

This work would not have been possible without financial support from the German Technical Cooperation. We would like to thank the Environment Forest and Climate Change Commission (EFCCC) of Ethiopia, particularly H.E. Ato Kebede Yimam and Dr. Tefera Mengistu, for their commitment to this project and for providing us with support staff from the commission and at the regional offices. The regional REDD+ team were responsible for all regional needs, including the stakeholder engagement and logistics of the two workshops conducted in Bahir Dar. These events would not have materialized without their support. Finally, we would like to extend a special thanks to all the experts from the region that participated in the inception and validation workshops to help develop the methodology and validate the outcomes.

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8 Appendix 1: Workshops

Two workshops were conducted in Bahir Dar City, Amhara region with regional stakeholders.

8.1 Inception Workshop

This table below presents an example of how criteria identified at the workshop was summarized.

Table 5 | Summary of original identified option and criteria from March 2019 workshop

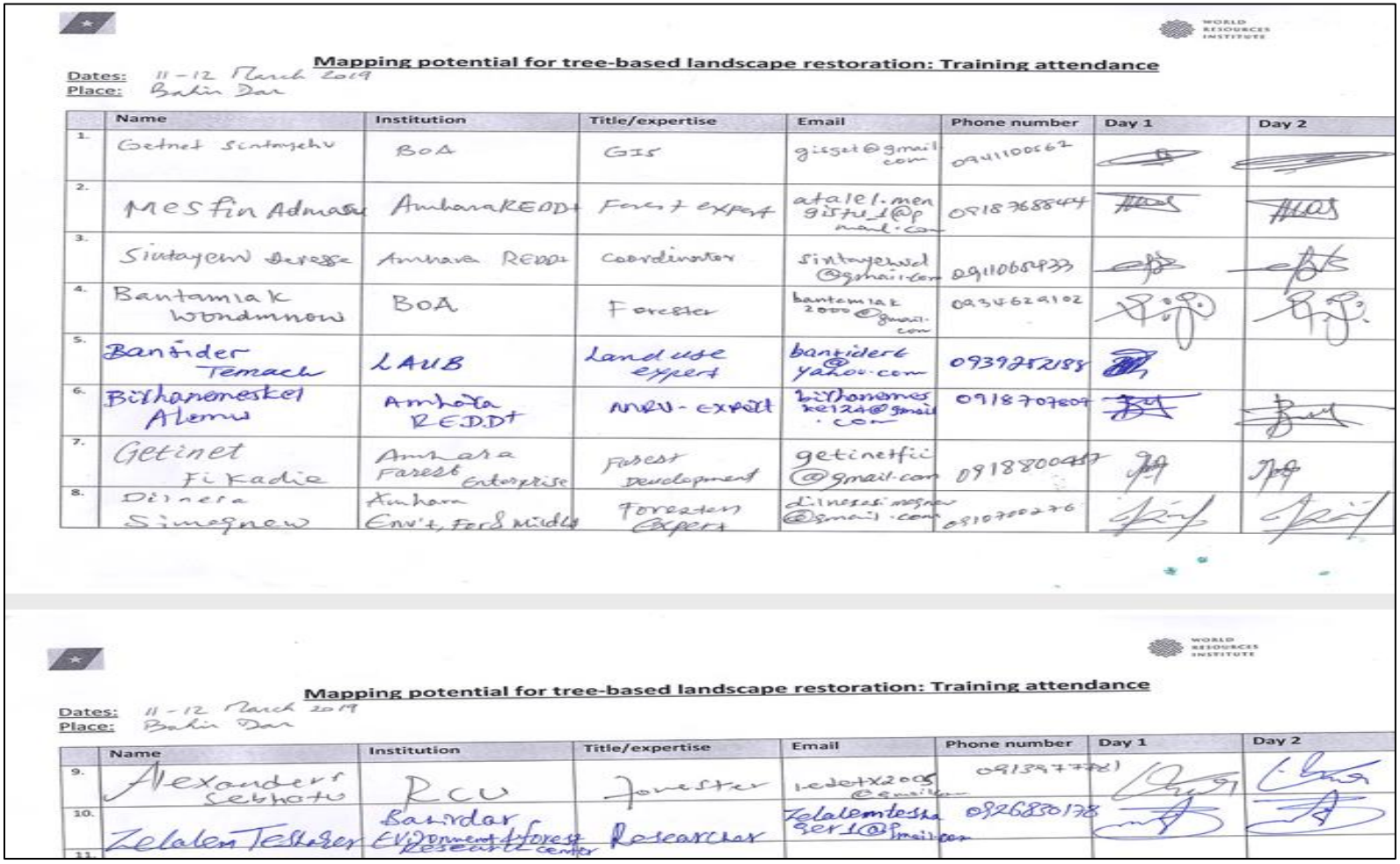
SUMMARY OF IDENTIFIED INTERVENTION OPTIONS															
Aggregated for mapping	Agri-silviculture				Woodlots		Silvopastoral Systems			Commercial Plantation	AfR (Afforestation reforestation)	Improved Management of Forest and woodlands		
Original workshop output	Managing trees on farmland	Alley Cropping	Boundary trees (farmland)	Taguia practices	Homesteads and woodlots	Buffer Zone (Roads, Waterbodies, Gullies)	Multipurpose tree planting in grazing land	Bee keeping/Bee forage tree planting	Fodder tree plating	Commercial plantation	AfR	Sustainable forest management (PFM)	Conservation and improved management of existing forest resources	Area Closures
Slope-normal soil (%)	<60									30-60%				
Slope-acidic soil (%)	N/A									≤30%				
rainfall (mm)										≥1000				

SUMMARY OF IDENTIFIED INTERVENTION OPTIONS														
Aggregated for mapping / **Original workshop output**	Agri-silviculture				Woodlots		Silvopastoral Systems			Commercial Plantation	AfR (Afforestation reforestation)	Improved Management of Forest and woodlands		
	Managing trees on farmland	Alley Cropping	Boundary trees (farmland)	Taguia practices	Homesteads and woodlots	Buffer Zone (Roads, Waterbodies, Gullies)	Multipurpose tree planting in grazing land	Bee keeping/Bee forage tree planting	Fodder tree plating	Commercial plantation	AfR	Sustainable forest management (PFM)	Conservation and improved management of existing forest resources	Area Closures
Distance from Road (km)										10				
Altitude (m)										1500-3200				
Area (ha)	small scale (not commercial, <50)									large scale (≥50)				
Location	farmland													
Max. tree density-tree cover (%)	<30													
Max. tree density-tree number (count/ha)	<50													
Agroclimatic exclusion	Alpine & Bereha (desert)													

Participants

List of participants who attended the inception workshop. Several participants also attended the validation workshop.

Box 6 | List of inception workshop participants in March 2019



Mapping potential for tree-based landscape restoration: Training attendance

Dates: 11 - 12 March 2019
Place: Bahir Dar

	Name	Institution	Title/expertise	Email	Phone number	Day 1	Day 2
1.	Getnet Sintayehu	BoA	GIS	gisget@gmail.com	0911100562		
2.	Mesfin Admasu	AmharaREDD+	Forest expert	atalel.mengistu_1@gmail.com	0918768844		
3.	Sintayehu Dereje	Amhara REDD+	Coordinator	sintayehud@gmail.com	0911068433		
4.	Bantamlak Wondmnow	BoA	Forester	bantamlak2000@gmail.com	0936629102		
5.	Banider Temach	LAUB	Land use expert	banidere@yahoo.com	0939252188		
6.	Birhanemeskel Alemu	Amhara REDD+	MRV - expert	birhanemes2124@gmail.com	0918707604		
7.	Getinet Fikadie	Amhara Forest Enterprise	Forest Development	getinetfi@gmail.com	0918800457		
8.	Dinesa Simegnew	Amhara Env't, Ford & Wildl	Forestry Expert	dinesasimegnew@gmail.com	0910700276		

Mapping potential for tree-based landscape restoration: Training attendance

Dates: 11 - 12 March 2019
Place: Bahir Dar

	Name	Institution	Title/expertise	Email	Phone number	Day 1	Day 2
9.	Alexander Sebhatu	RCU	Forester		0913977781		
10.	Zelalem Teshager	Bahirdar Environment & Forest Research Center	Researcher	zelalemtesha9er1@gmail.com	0926830178		
11.							

8.2 Validation Workshop

The validation workshop was conducted on August 22, 2019, in Bahir Dar. 12 participants from relevant organizations participated. Preliminary results from the project were presented and several recommendations for new interventions, and modifications to the original seven interventions, were made. As a result, the number of the final identified intervention options grew from 7 to 15. The following updates were made to the draft maps based on these and other recommendations from regional representatives.

Table 6 | Recommended updates from the validation workshop, August 2019

Current or new	Change and additions suggested at the workshop	New/change	Description, purpose or activity (Shared by REDD+, primarily adapted from UNIQUE study)	Criteria	Value
IMDNF	Split this into woodlands & Forest	Improved Management of Degraded Natural Forest (IMDNF)	Enrichment planting and protection through PFM	Tree cover %	60
	Specify degradation status and develop maps only for Degraded Natural Forest (exclude intact Forest/Non-degraded forest from the mapping)			NDVI trend	10 years, 2-time stamp (2010-2019), if the recent (2019) NDVI is less than the older (2010), and NDVI is <0.6; include as degraded that needs management.
	Split woodlands into two- the Western lowlands of Amhara (combretum-terminalia) and	Improved Management of Combretum-Terminalia woodlands (Western Lowlands of Amhara)	Protection, preventing overexploitation, managing fires, and improving productivity (NTFP	Split the current woodlands map and focus on the western Lowlands of Amhara. Frankincense	Include woodland class of current landuse located in the Western

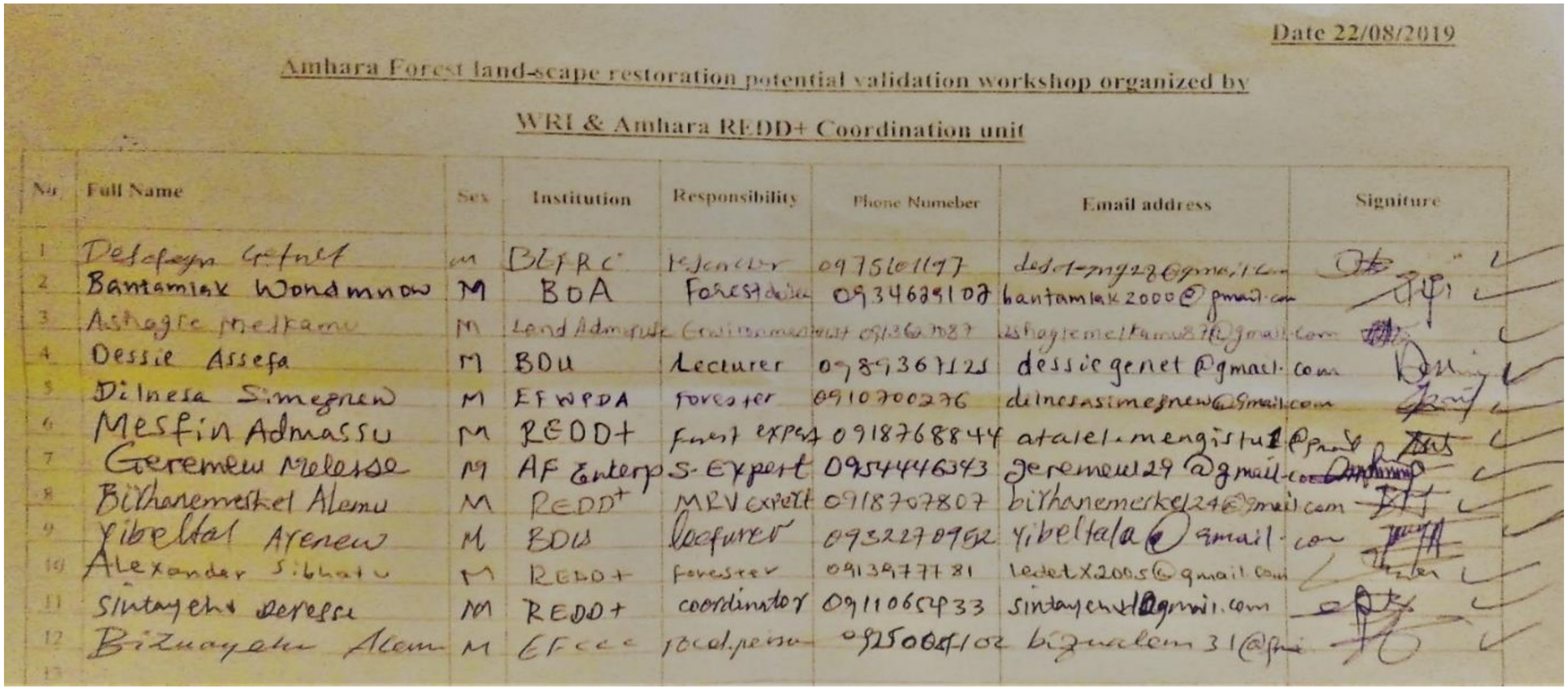
Current or new	Change and additions suggested at the workshop	New/change	Description, purpose or activity (Shared by REDD+, primarily adapted from UNIQUE study)	Criteria	Value
	Eastern lowland (Acacia - Commiphora) woodlands.		production) through PFM	development is the focus here.	Lowlands of Amhara region
		Improved Management of Acacia *Commiphora* and Boswellia woodlands (Eastern Lowlands of Amhara)	Protection, preventing overexploitation, managing fires, and improving productivity (NTFP production) through PFM	Split the current woodlands map and focus on Eastern Lowlands of Amhara. Myrrh (Commiphora) and gum arabic (Boswellia) development is the focus here.	Include woodland class of current landuse located in the Eastern lowlands Amhara region
New proposed additions	Additions	Biodiversity Priority Area (BPA) Parks, Community conservation area, KBA, NFPAs, etc.		Include in a map as separate FLR. Management options should be left to the owners/administrators of these land designations	Map the available protected area and NFPAs
		Afro-alpine and sub-afro-alpine ecosystems development and management	Restoration by natural regeneration and limited yet purposeful tree planting for ecosystem conservation (biodiversity protection, watershed management) through PFM	Include as separate FLR	Adapt the UNIQUE criteria
		Church (religious) Forest development and management		Include if available	

Current or new	Change and additions suggested at the workshop	New/change	Description, purpose or activity (Shared by REDD+, primarily adapted from UNIQUE study)	Criteria	Value
		Degraded formerly cultivated land no longer productive for agriculture		Include using soil maps	
		Restoration of riverine Forest	Protection and restocking of riversides with suitable tree species	Identify using Woody Biomass study and Biodiversity Institute literature on this subject; Trace on Google Earth; and/or use search distance of 30m, and if current forests fall within this distance, consider them riverine forests.	
		Buffer planting around wetlands and lakes, reservoirs, dams		Identify buffer zones from the current authorities managing these resources.	

Participants

A validation workshop was conducted in August 2019 to discuss and get feedback on the draft output maps and statistics. Participants who attended the workshop can be found in Figure 17.

Box 7 | List of validation workshop participants



Date 22/08/2019

Amhara Forest land-scape restoration potential validation workshop organized by

WRI & Amhara REDD+ Coordination unit

No	Full Name	Sex	Institution	Responsibility	Phone Numeber	Email address	Signiture
1	Desalegn Getnet	M	BLFRC	Researcher	0975601177	[illegible]	
2	Bantamlak Wondmnow	M	BoA	Forest dev.	0934629107	bantamlak2000@gmail.com	
3	Ashagre Melkamu	M	Land Admin.	Environment	[illegible]	[illegible]@gmail.com	
4	Dessie Assefa	M	BDU	Lecturer	0989367125	dessiegenet@gmail.com	
5	Dilnesa Simegnew	M	EFWPDA	Forester	0910700276	dilnesasimegnew@gmail.com	
6	Mesfin Admassu	M	REDD+	Forest expert	0918768844	atalel.mengistu1@[illegible]	
7	Geremew Melesse	M	AF Enterp.	S. Expert	0954446343	geremew29@gmail.com	
8	Birhanemeskel Alemu	M	REDD+	MRV expert	0918707807	birhanemerkel24@gmail.com	
9	Yibeltal Arenew	M	BDU	lecturer	0932270952	yibeltala@gmail.com	
10	Alexander Sibhatu	M	REDD+	forester	0913977781	ledetx2005@gmail.com	
11	Sintayehu Deresse	M	REDD+	coordinator	0911065433	sintayehud@gmail.com	
12	Bizuayehu Alem	M	EF[illegible]	focal person	0925004102	bizualem31@[illegible]	
13							

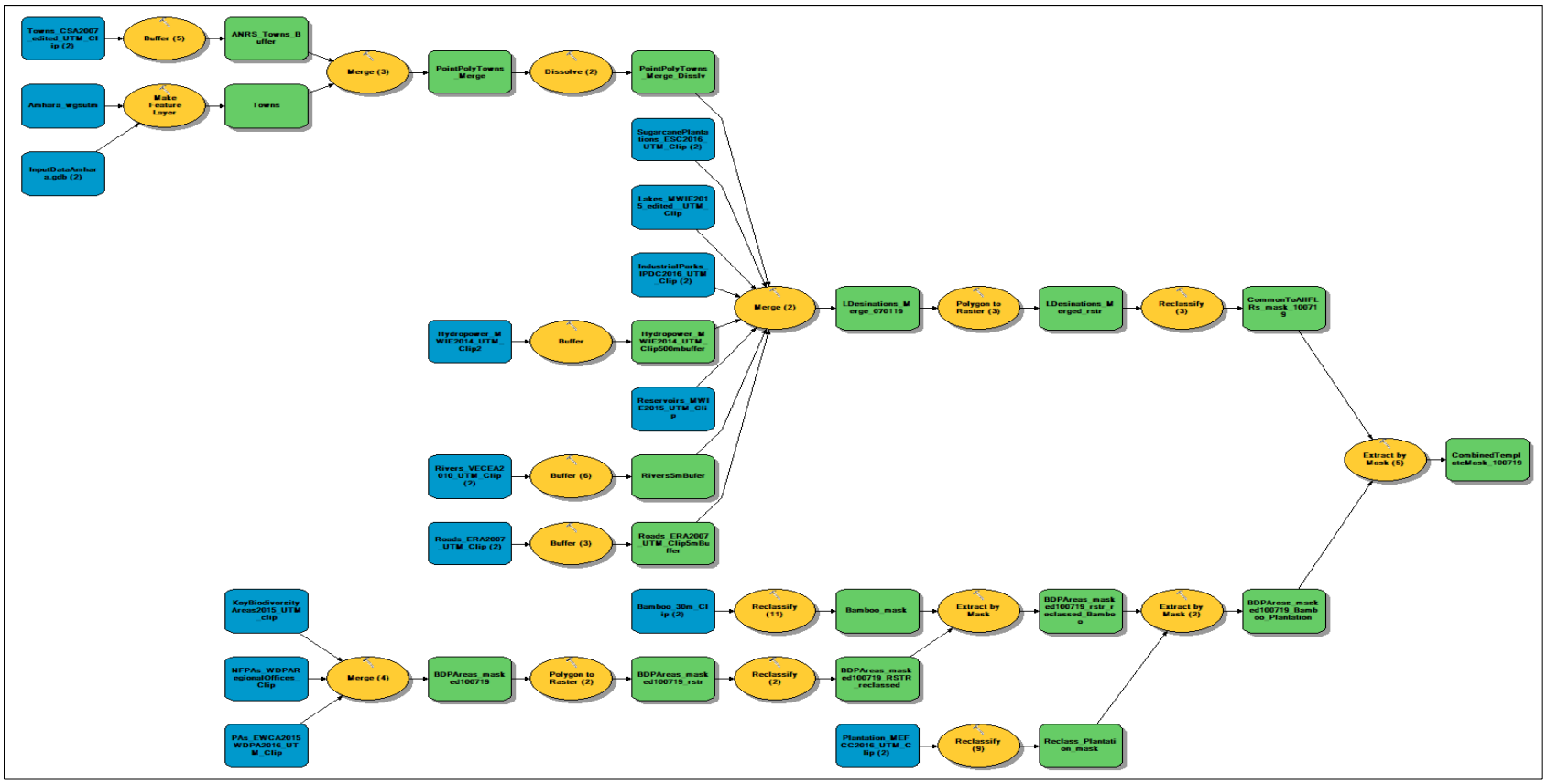
9 Appendix 2: Spatial Modelling

Each intervention criteria were translated into ArcGIS model builder to produce the included maps and statistics. To spare excess technical jargon, we did not include complete list of all models and explanations in this main report.

9.1 General Masking Model to Exclude Ineligible Areas from Analysis

This model is included to demonstrate the approach that is relevant to all intervention-specific models. It addresses the first section of set criteria, listed as "Exclusion from all Interventions" (Table 2). Using this model, we exclude all areas of the region that are not eligible to be included in restoration mapping for one of the reasons provided in the same section of Table 2. The output of this model is used as an input for all intervention-specific modeling in addition to respective intervention specific criteria. BDPA interventions were the exception to this process, and part of the model was ignored to map that specific intervention.

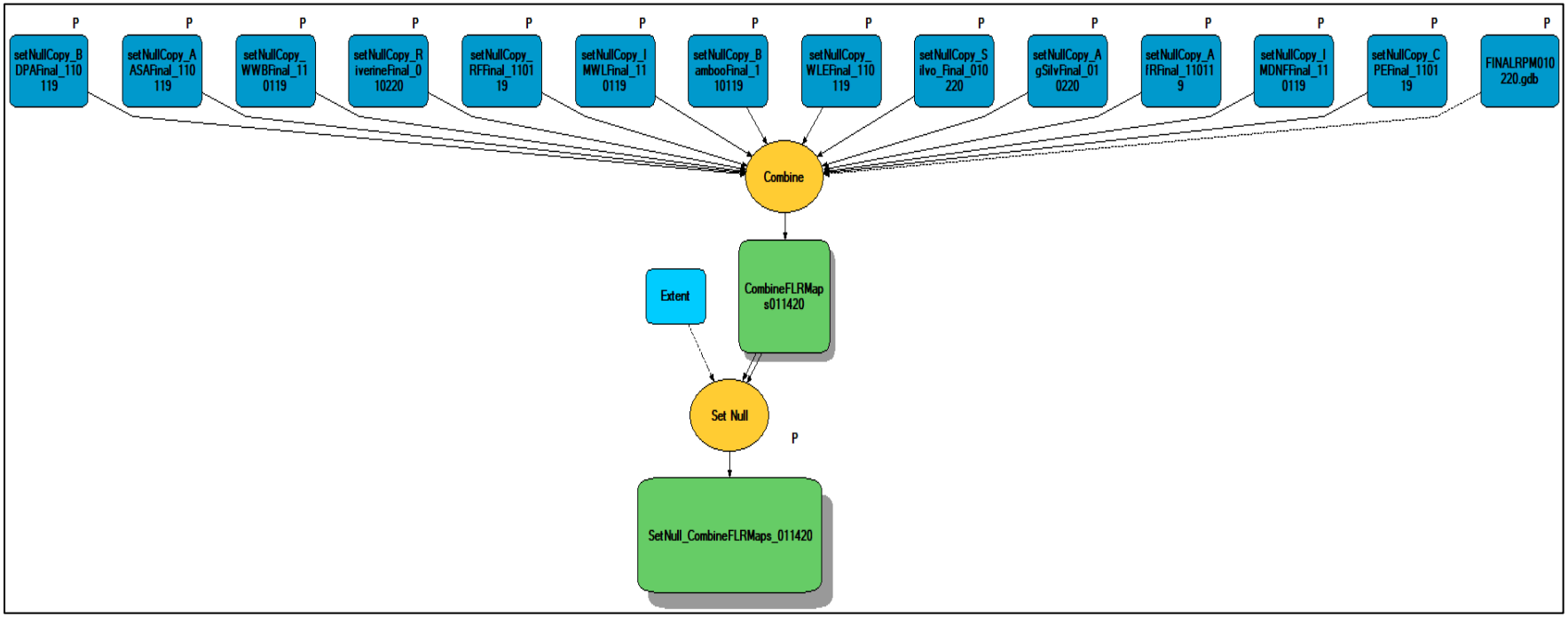
Figure 15 | Model to exclude ineligible areas



9.2 A Model to Combine Individual FLR Types into Single Map

This model uses the ArcGIS Analysis tool to combine all individual maps into single map. The resulting combined map includes all possible combination scenarios, showing both areas with overlaps and areas that are exclusively available for the identified interventions. Each possible combination is identified using a unique color code and intervention acronym (GIS key), as explained under the combined map section.

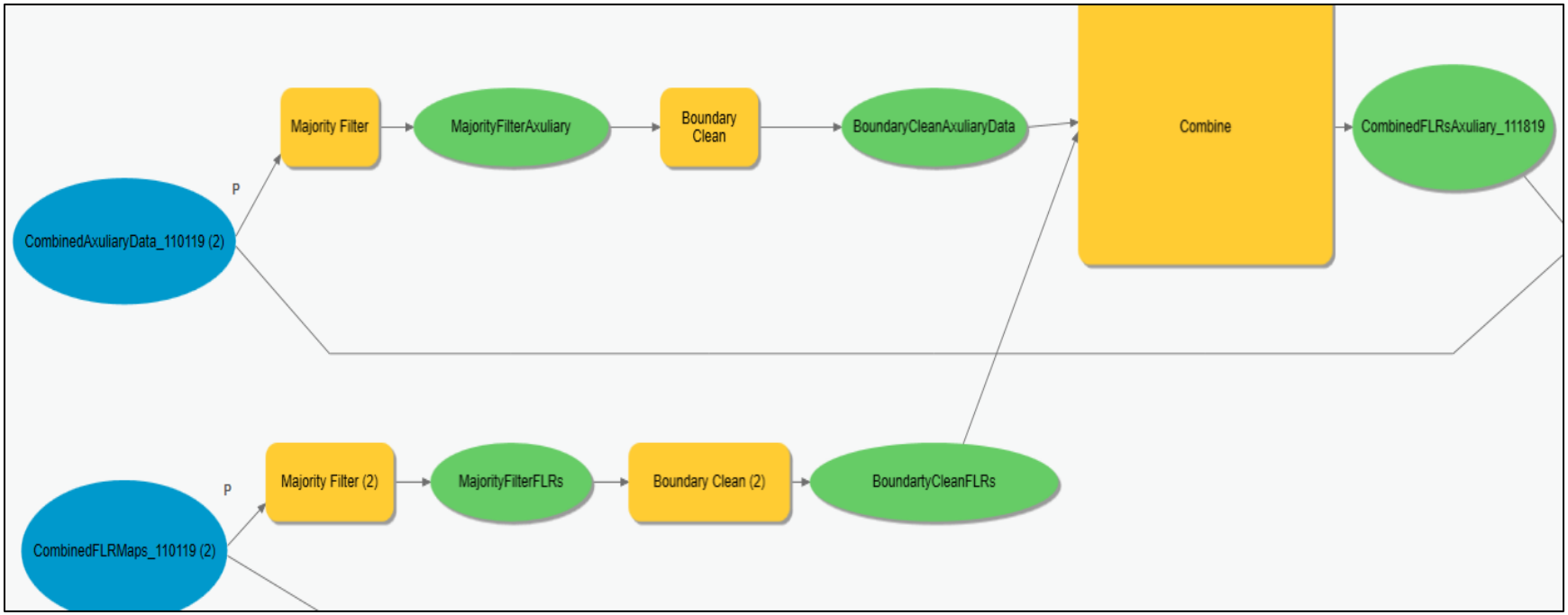
Figure 16 | Model to combine all potential maps



9.3 Merging the Combined FLR Map with Auxiliary Data

Likewise, the combined interventions map was further combined with ancillary data (outlined in Appendix 3) that will aid implementation and local planning. The fields from the three main ancillary data layers and the combined interventions map are merged. All information is stored as an attribute table on pixel basis.

Figure 17 | Model to combine restoration intervention map with ancillary data



10 Appendix 3: Ancillary Data Included in Final Analysis

10.1 Potential Natural Vegetation Atlas of Ethiopia (PNV)

According to Friis, Sebsebe, and van Breguel, authors of this atlas:

> The new vegetation atlas benefits from the complete taxonomic revision for the Flora of Ethiopia and Eritrea made during the years 1980–2009, as well as intensive field studies of the vegetation and flora that have been carried out over nearly the entire country in connection with the Flora project. This atlas is a successor to two well-known vegetation maps of Ethiopia, one published by Pichi Sermolli in 1957, and one which formed part of a vegetation map of the whole of Africa by Frank White in 1983. Both were produced at the scale of 1:5,000,000. For the new atlas definitions of previously accepted vegetation types have been completely revised, and for the first time, it has been attempted to map saline vegetation types. The atlas has been produced using a digital elevation model with a resolution of 90 x 90 meres in connection with GIS technology, allowing a much finer resolution than on previous maps. It is also based on an analysis of information about approximately 1300 species of woody plants in the completed Flora of Ethiopia and Eritrea.

10.2 Ecological Land Units Map (ELU)

An overview of this map, published by the Association of American Geographers (AAG) states:

> The map was produced by a team led by Roger Sayre, Ph.D., Senior Scientist for Ecosystems at the USGS Land Change Science Program. It is a mosaic of almost 4,000 unique ecological areas called Ecological Land Units (ELUs) based on four factors that are key in determining the makeup of ecosystems. Three of these--**bioclimate**, **landforms**, and **rock type**--are physical phenomena that drive the formation of soils and the distribution of vegetation. The fourth, **land cover**, is the vegetation that is found in a location as a response to the physical factors.

10.3 Africa Terrestrial Ecosystems Map

An overview of this report, published by the Association of American Geographers, states:

> Terrestrial ecosystems and vegetation of Africa were classified and mapped as part of a larger effort and global protocol (GEOSS – the Global Earth Observation System of Systems), which includes an activity to map terrestrial ecosystems of the earth in a standardized, robust, and practical manner, and at the finest possible spatial resolution. To model the potential distribution of ecosystems, new

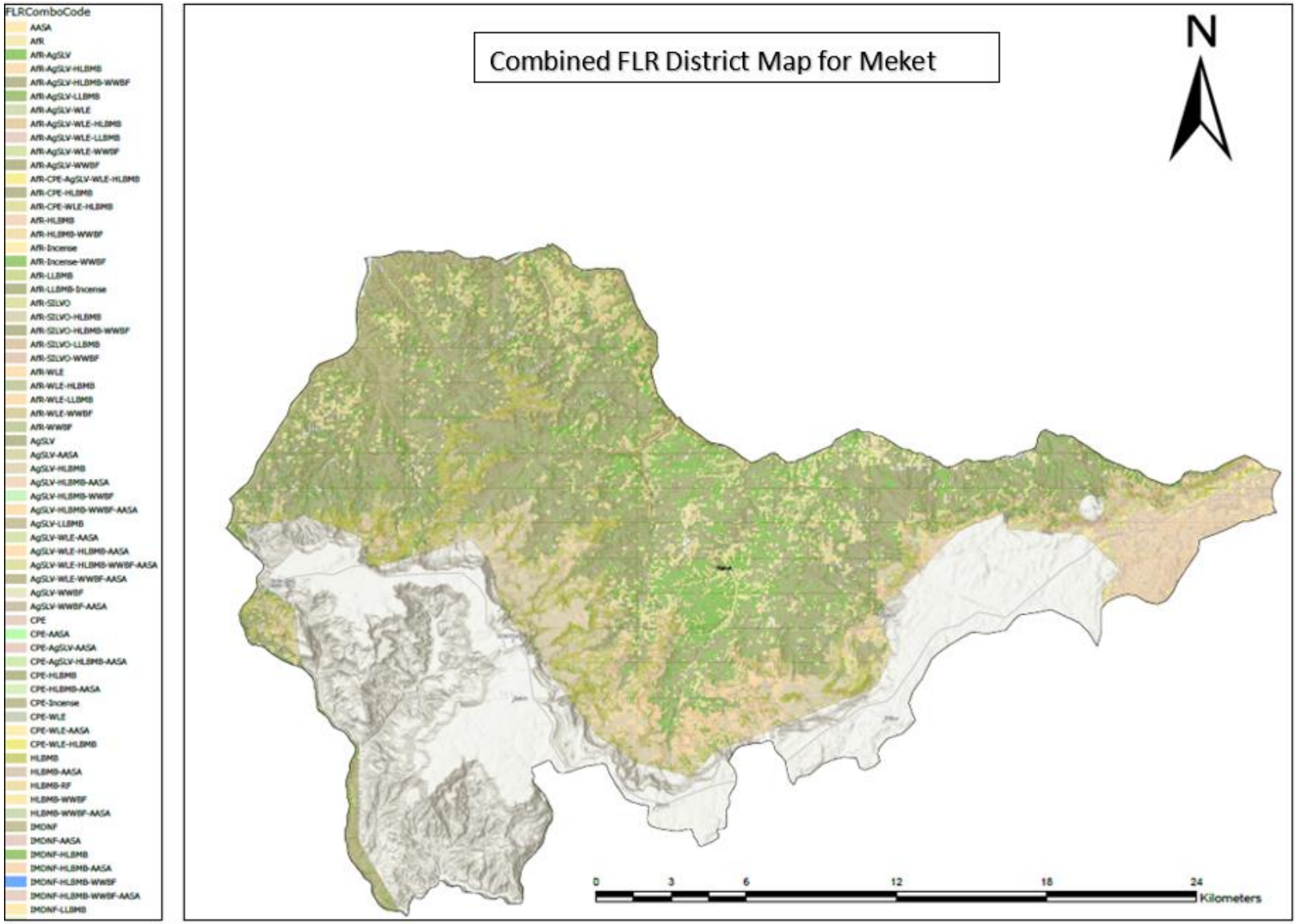
continental datasets for several key physical environment data layers (including coastline, landforms, surficial lithology, and bioclimates) were developed at spatial and classification resolutions finer than existing similar data layers. A hierarchical vegetation classification was developed by African ecosystem scientists and vegetation geographers, who also provided sample locations of the newly classified vegetation units. ---- A total of 126 macrogroup types were mapped, each with multiple, repeating occurrences on the landscape. The modeling effort was implemented at a base spatial resolution of 90 m. In addition to creating several rich, new continent-wide biophysical data layers describing African vegetation and ecosystems, our intention was to explore feasible approaches to rapidly moving this type of standardized, continent-wide, ecosystem classification and mapping effort forward. Please refer to the booklet found at this web address for the details.

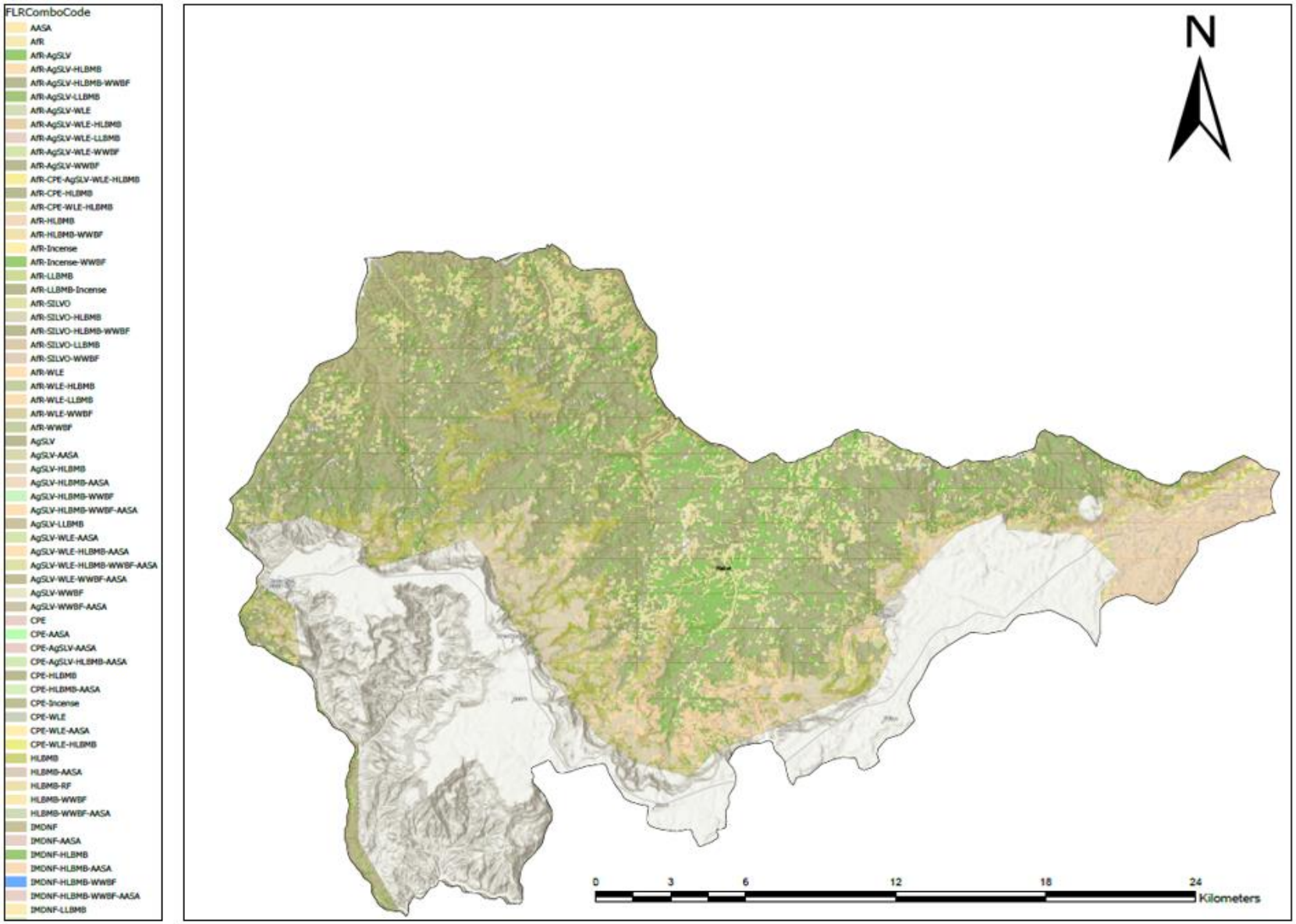
11 Appendix 4: Meket District Map as an Example of Combined District Maps

The combined interventions map was merged with rich auxiliary data from national and global sources (Appendix 3). The additional information embedded in the attribute table[11] is critical information for implementation by aiding practitioners and planners for matching restoration practices and species with site characteristics. Lastly, district maps are printed on poster-sized pdf pages, with each page representing a single district.[12] Each map page contains the map display, attribute table with 7 or 8 columns of key information, and the legend. For easier analysis, the legend for each page contains only information relevant to the target district instead of entire region. District stakeholders and practitioners will find these maps useful planning tools as they can be also printed at high resolution posters for field work or wall maps. The "FLR (combo) Code" column is referring to which FLR type(s) is/are suitable under the conditions for that row. That information is also spatial identifiable using the legend and the map display.

[11] See some rows of displayed attribute of Meket district, which has 7 columns with critical info (column names from "PNV_Name", top left - "FLR Code", bottom right)
[12] See the map and enhanced snapshots below.

Figure 18 | Meket example of district maps




FLRComboCode
AASA
AfR
AfR-AgSLV
AfR-AgSLV-HLBMB
AfR-AgSLV-HLBMB-WWBF
AfR-AgSLV-LLBMB
AfR-AgSLV-WLE
AfR-AgSLV-WLE-HLBMB
AfR-AgSLV-WLE-LLBMB
AfR-AgSLV-WLE-WWBF
AfR-AgSLV-WWBF
AfR-CPE-AgSLV-WLE-HLBMB
AfR-CPE-HLBMB
AfR-CPE-WLE-HLBMB
AfR-HLBMB
AfR-HLBMB-WWBF
AfR-Incense
AfR-Incense-WWBF
AfR-LLBMB
AfR-LLBMB-Incense
AfR-SILVO
AfR-SILVO-HLBMB
AfR-SILVO-HLBMB-WWBF
AfR-SILVO-LLBMB
AfR-SILVO-WWBF
AfR-WLE
AfR-WLE-HLBMB
AfR-WLE-LLBMB
AfR-WLE-WWBF
AfR-WWBF
AgSLV
AgSLV-AASA
AgSLV-HLBMB
AgSLV-HLBMB-AASA
AgSLV-HLBMB-WWBF
AgSLV-HLBMB-WWBF-AASA
AgSLV-LLBMB
AgSLV-WLE-AASA
AgSLV-WLE-HLBMB-AASA
AgSLV-WLE-HLBMB-WWBF-AASA
AgSLV-WLE-WWBF-AASA
AgSLV-WWBF
AgSLV-WWBF-AASA
CPE
CPE-AASA
CPE-AgSLV-AASA
CPE-AgSLV-HLBMB-AASA
CPE-HLBMB
CPE-HLBMB-AASA
CPE-Incense
CPE-WLE
CPE-WLE-AASA
CPE-WLE-HLBMB
HLBMB
HLBMB-AASA
HLBMB-RF
HLBMB-WWBF
HLBMB-WWBF-AASA
IMDNF
IMDNF-AASA
IMDNF-HLBMB
IMDNF-HLBMB-AASA
IMDNF-HLBMB-WWBF
IMDNF-HLBMB-WWBF-AASA
IMDNF-LLBMB
N
0
3
6
12
18
24
Kilometers

Box 8 | Partial view of relevant 7 columns of the attribute of Meket district map

PNV_NAME (Vegetation Atlas)	formation (Africa Terresterial Ecosystems)	Macrogroup (Africa Terresterial Ecosystems)	EF (Africa Terresterial Ecosystems)	ELU (Ecological Landmap units)	FLR Code (Restoration	Area (ha)
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	AgSLV-AASA	15967.44
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	WLE-AASA	2107.62
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	WLE	18.27
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	AfR	52.83
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	AgSLV	64.8
Montane Ericaceous belt	1.A.3 Tropical Montane Humid Forest	Moist Evergreen Montane Forest	Cool Wet Low Hills Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cool Wet Hills on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	AASA	1642.5
Montane Ericaceous belt	1.A.3 Tropical Montane Humid Forest	Moist Evergreen Montane Forest	Cool Wet Low Hills Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cool Wet Hills on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	AfR	13.59
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	IMDNF-AASA	1514.34
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	IMDNF	14.04
Montane Ericaceous belt	1.A.3 Tropical Montane Humid Forest	Moist Evergreen Montane Forest	Cool Wet Low Hills Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cool Wet Hills on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	WLE-AASA	172.08
Montane Ericaceous belt	1.A.3 Tropical Montane Humid Forest	Moist Evergreen Montane Forest	Cool Wet Low Hills Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cool Wet Hills on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	AgSLV-AASA	647.19
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	AgSLV-WLE-AASA	388.35
Montane Ericaceous belt	1.A.3 Tropical Montane Humid Forest	Moist Evergreen Montane Forest	Cool Wet Low Hills Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cool Wet Hills on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	IMDNF-AASA	205.38
Montane Ericaceous belt	3.A.2 Warm Desert & Semi-Desert Scrub & Grassland	Eastern African Acacia - Commiphora Woodland	Cold Wet Low Mountains Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cold Wet Mountains on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	SILVO-AASA	2594.88
Montane Ericaceous belt	1.A.3 Tropical Montane Humid Forest	Moist Evergreen Montane Forest	Cool Wet Low Hills Basic Volcanics Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Cool Wet Hills on Non-Acidic Volcanics with Grassland, Shrub, or Scrub	SILVO-AASA	165.96

The GIS files contain more columns, hidden from this snapshot but it can be turned on. Similar district maps are produced for all Woredas (district) of entire Amhara region. The folder included with database contains these maps of all districts.

12 Appendix 5: Exclusively Available FLR Area

1IMDNF	2Af11RF	3CPE	4AGSLV	5SILVO	66WLE	7LLBMB	8HLBMB	9MYRRH	10INCENSE	11RF	12RIVN	13WWBF	14AASA	15BDPA	Count of Overlaps	Area (ha)	FLR Combo Code
1IMDNF															1	**106,117**	**1IMDNF**
	2AFR														1	**871,032**	**2AFR**
		3CPE													1	**35,568**	**3CPE**
			4AGSLV												1	**1,549,939**	**4AGSLV**
				5SILVO											1	**2,986**	**5SILVO**
					6WLE										1	**219,530**	**6WLE**
						7LLBMB									1	**308,703**	**7LLBMB**
							8HLBMB								1	**441,742**	**8HLBMB**
								9MYRRH							1	**55,329**	**9MYRRH**
									10INCENSE						1	**563,485**	**10INCENSE**
										11RF					1	**28**	**11RF**
											12RIVN				1	**1,763**	**12RIVN**
												13WWBF			1	**93,461**	**13WWBF**
													14AASA		1	**115,942**	**14AASA**
														15BDPA	1	**2,786,785**	**15BDPA**
Total															**15**	**7,152,410**	

13 Appendix 6: Overlapping FLR Area

IMDNF	*2AfRF*	*3CPE*	*4AGSLV*	*5SILVO*	*66WLE*	*7LLBMB*	*8HLBMB*	*9MYRRH*	*0INCENSE*	*RF*	*2RIVN*	*3WWBF*	*4AASA*	*5BDPA*	*Number of Overlaps*	*Area (ha)*	*FLR Combo Code*
IMDNF										RF					2	4	*IMDNF-RF*
IMDNF												WWBF			2	2,953	*IMDNF-3WWBF*
IMDNF												WWBF	AASA		3	1	*IMDNF-3WWBF-4AASA*
IMDNF													AASA		2	10,204	*IMDNF-4AASA*
IMDNF						LLBMB									2	25,162	*IMDNF-7LLBMB*
IMDNF						LLBMB						WWBF			3	609	*IMDNF-7LLBMB-3WWBF*
IMDNF							HLBMB								2	30,016	*IMDNF-8HLBMB*
IMDNF							HLBMB			RF					3	1	*IMDNF-8HLBMB-RF*
IMDNF							HLBMB					WWBF			3	218	*IMDNF-8HLBMB-3WWBF*
IMDNF							HLBMB					WWBF	AASA		4	29	*IMDNF-8HLBMB-3WWBF-4AASA*
IMDNF							HLBMB						AASA		3	9,120	*IMDNF-8HLBMB-4AASA*
	AFR								0INCENSE						2	288,683	*2AFR-0INCENSE*
	AFR								0INCENSE			WWBF			3	7,164	*2AFR-0INCENSE-3WWBF*
	AFR									RF					2	3	*2AFR-RF*
	AFR											WWBF			2	25,274	*2AFR-3WWBF*
	AFR	CPE													2	32,320	*2AFR-3CPE*
	AFR	CPE							0INCENSE						3	850	*2AFR-3CPE-0INCENSE*
	AFR	CPE							0INCENSE			WWBF			4	3	*2AFR-3CPE-0INCENSE-3WWBF*
	AFR	CPE										WWBF			3	61	*2AFR-3CPE-3WWBF*
	AFR	CPE	AGSLV												3	27,321	*2AFR-3CPE-4AGSLV*

	AFR	CPE	AGSLV									WWBF			4	196	*2AFR-3CPE-4AGSLV-3WWBF*
	AFR	CPE	AGSLV		WLE										4	1,110	*2AFR-3CPE-4AGSLV-6WLE*
	AFR	CPE	AGSLV		WLE							WWBF			5	9	*2AFR-3CPE-4AGSLV-6WLE-3WWBF*
	AFR	CPE	AGSLV		WLE	LLBMB									5	116	*2AFR-3CPE-4AGSLV-6WLE-7LLBMB*
	AFR	CPE	AGSLV		WLE	LLBMB						WWBF			6	3	*2AFR-3CPE-4AGSLV-6WLE-7LLBMB-3WWBF*
	AFR	CPE	AGSLV		WLE		HLBMB								5	483	*2AFR-3CPE-4AGSLV-6WLE-8HLBMB*
	AFR	CPE	AGSLV		WLE		HLBMB					WWBF			6	0	*2AFR-3CPE-4AGSLV-6WLE-8HLBMB-3WWBF*
	AFR	CPE	AGSLV			LLBMB									4	2,925	*2AFR-3CPE-4AGSLV-7LLBMB*
	AFR	CPE	AGSLV			LLBMB						WWBF			5	39	*2AFR-3CPE-4AGSLV-7LLBMB-3WWBF*
	AFR	CPE	AGSLV				HLBMB								4	14,517	*2AFR-3CPE-4AGSLV-8HLBMB*
	AFR	CPE	AGSLV				HLBMB					WWBF			5	34	*2AFR-3CPE-4AGSLV-8HLBMB-3WWBF*
	AFR	CPE			WLE										3	2,250	*2AFR-3CPE-6WLE*
	AFR	CPE			WLE							WWBF			4	13	*2AFR-3CPE-6WLE-3WWBF*
	AFR	CPE			WLE	LLBMB									4	337	*2AFR-3CPE-6WLE-7LLBMB*
	AFR	CPE			WLE	LLBMB						WWBF			5	4	*2AFR-3CPE-6WLE-7LLBMB-3WWBF*
	AFR	CPE			WLE		HLBMB								4	723	*2AFR-3CPE-6WLE-8HLBMB*
	AFR	CPE			WLE		HLBMB					WWBF			5	0	*2AFR-3CPE-6WLE-8HLBMB-3WWBF*
	AFR	CPE				LLBMB									3	3,797	*2AFR-3CPE-7LLBMB*
	AFR	CPE				LLBMB			0INCENSE						4	1,274	*2AFR-3CPE-7LLBMB-0INCENSE*
	AFR	CPE				LLBMB			0INCENSE			WWBF			5	4	*2AFR-3CPE-7LLBMB-0INCENSE-3WWBF*

	AFR	CPE				LLBMB						WWBF			4	17	*2AFR-3CPE-7LLBMB-3WWBF*
	AFR	CPE				LLBMB		MYRRH							4	1,063	*2AFR-3CPE-7LLBMB-9MYRRH*
	AFR	CPE				LLBMB		MYRRH				WWBF			5	17	*2AFR-3CPE-7LLBMB-9MYRRH-3WWBF*
	AFR	CPE					HLBMB								3	17,110	*2AFR-3CPE-8HLBMB*
	AFR	CPE					HLBMB					WWBF			4	19	*2AFR-3CPE-8HLBMB-3WWBF*
	AFR	CPE						MYRRH							3	2,195	*2AFR-3CPE-9MYRRH*
	AFR	CPE						MYRRH				WWBF			4	28	*2AFR-3CPE-9MYRRH-3WWBF*
	AFR		AGSLV												2	871,940	*2AFR-4AGSLV*
	AFR		AGSLV							RF					3	1	*2AFR-4AGSLV-RF*
	AFR		AGSLV									WWBF			3	17,563	*2AFR-4AGSLV-3WWBF*
	AFR		AGSLV		WLE										3	83,705	*2AFR-4AGSLV-6WLE*
	AFR		AGSLV		WLE							WWBF			4	2,979	*2AFR-4AGSLV-6WLE-3WWBF*
	AFR		AGSLV		WLE	LLBMB									4	29,524	*2AFR-4AGSLV-6WLE-7LLBMB*
	AFR		AGSLV		WLE	LLBMB						WWBF			5	518	*2AFR-4AGSLV-6WLE-7LLBMB-3WWBF*
	AFR		AGSLV		WLE		HLBMB								4	12,067	*2AFR-4AGSLV-6WLE-8HLBMB*
	AFR		AGSLV		WLE		HLBMB					WWBF			5	120	*2AFR-4AGSLV-6WLE-8HLBMB-3WWBF*
	AFR		AGSLV			LLBMB									3	301,575	*2AFR-4AGSLV-7LLBMB*
	AFR		AGSLV			LLBMB						WWBF			4	3,599	*2AFR-4AGSLV-7LLBMB-3WWBF*
	AFR		AGSLV				HLBMB								3	214,169	*2AFR-4AGSLV-8HLBMB*
	AFR		AGSLV				HLBMB			RF					4	0	*2AFR-4AGSLV-8HLBMB-RF*
	AFR		AGSLV				HLBMB					WWBF			4	1,301	*2AFR-4AGSLV-8HLBMB-3WWBF*
	AFR			SILVO											2	191,951	*2AFR-5SILVO*
	AFR			SILVO						RF					3	0	*2AFR-5SILVO-RF*

	AFR			SILVO								WWBF			3	11,821	*2AFR-5SILVO-3WWBF*
	AFR			SILVO		LLBMB									3	6,535	*2AFR-5SILVO-7LLBMB*
	AFR			SILVO		LLBMB						WWBF			4	145	*2AFR-5SILVO-7LLBMB-3WWBF*
	AFR			SILVO			HLBMB								3	68,973	*2AFR-5SILVO-8HLBMB*
	AFR			SILVO			HLBMB					WWBF			4	500	*2AFR-5SILVO-8HLBMB-3WWBF*
	AFR				WLE										2	97,130	*2AFR-6WLE*
	AFR				WLE					RF					3	0	*2AFR-6WLE-RF*
	AFR				WLE							WWBF			3	1,104	*2AFR-6WLE-3WWBF*
	AFR				WLE	LLBMB									3	51,056	*2AFR-6WLE-7LLBMB*
	AFR				WLE	LLBMB						WWBF			4	135	*2AFR-6WLE-7LLBMB-3WWBF*
	AFR				WLE		HLBMB								3	15,289	*2AFR-6WLE-8HLBMB*
	AFR				WLE		HLBMB					WWBF			4	33	*2AFR-6WLE-8HLBMB-3WWBF*
	AFR					LLBMB									2	314,267	*2AFR-7LLBMB*
	AFR					LLBMB			0INCENSE						3	433,787	*2AFR-7LLBMB-0INCENSE*
	AFR					LLBMB			0INCENSE			WWBF			4	2,384	*2AFR-7LLBMB-0INCENSE-3WWBF*
	AFR					LLBMB						WWBF			3	2,485	*2AFR-7LLBMB-3WWBF*
	AFR					LLBMB		MYRRH							3	38,210	*2AFR-7LLBMB-9MYRRH*
	AFR					LLBMB		MYRRH				WWBF			4	556	*2AFR-7LLBMB-9MYRRH-3WWBF*
	AFR						HLBMB								2	134,236	*2AFR-8HLBMB*
	AFR						HLBMB		0INCENSE						3	0	*2AFR-8HLBMB-0INCENSE*
	AFR						HLBMB					WWBF			3	404	*2AFR-8HLBMB-3WWBF*
	AFR							MYRRH							2	293,883	*2AFR-9MYRRH*
	AFR							MYRRH				WWBF			3	4,826	*2AFR-9MYRRH-3WWBF*
		CPE							0INCENSE						2	2,516	*3CPE-0INCENSE*
		CPE							0INCENSE			WWBF			3	8	*3CPE-0INCENSE-3WWBF*
		CPE										WWBF			2	89	*3CPE-3WWBF*

		CPE											AASA		2	851	*3CPE-4AASA*
		CPE	AGSLV												2	34	*3CPE-4AGSLV*
		CPE	AGSLV									WWBF			3	0	*3CPE-4AGSLV-3WWBF*
		CPE	AGSLV										AASA		3	1,549	*3CPE-4AGSLV-4AASA*
		CPE	AGSLV		WLE										3	2	*3CPE-4AGSLV-6WLE*
		CPE	AGSLV		WLE								AASA		4	12	*3CPE-4AGSLV-6WLE-4AASA*
		CPE	AGSLV		WLE	LLBMB									4	0	*3CPE-4AGSLV-6WLE-7LLBMB*
		CPE	AGSLV		WLE		HLBMB								4	0	*3CPE-4AGSLV-6WLE-8HLBMB*
		CPE	AGSLV		WLE		HLBMB						AASA		5	10	*3CPE-4AGSLV-6WLE-8HLBMB-4AASA*
		CPE	AGSLV			LLBMB									3	1	*3CPE-4AGSLV-7LLBMB*
		CPE	AGSLV				HLBMB								3	20	*3CPE-4AGSLV-8HLBMB*
		CPE	AGSLV				HLBMB					WWBF			4	0	*3CPE-4AGSLV-8HLBMB-3WWBF*
		CPE	AGSLV				HLBMB					WWBF	AASA		5	0	*3CPE-4AGSLV-8HLBMB-3WWBF-4AASA*
		CPE	AGSLV				HLBMB						AASA		4	1,960	*3CPE-4AGSLV-8HLBMB-4AASA*
		CPE			WLE										2	6,412	*3CPE-6WLE*
		CPE			WLE							WWBF			3	27	*3CPE-6WLE-3WWBF*
		CPE			WLE								AASA		3	33	*3CPE-6WLE-4AASA*
		CPE			WLE	LLBMB									3	2,366	*3CPE-6WLE-7LLBMB*
		CPE			WLE	LLBMB						WWBF			4	13	*3CPE-6WLE-7LLBMB-3WWBF*
		CPE			WLE		HLBMB								3	2,595	*3CPE-6WLE-8HLBMB*
		CPE			WLE		HLBMB					WWBF			4	1	*3CPE-6WLE-8HLBMB-3WWBF*
		CPE			WLE		HLBMB						AASA		4	43	*3CPE-6WLE-8HLBMB-4AASA*
		CPE				LLBMB									2	8,103	*3CPE-7LLBMB*
		CPE				LLBMB			0INCENSE						3	6,311	*3CPE-7LLBMB-0INCENSE*

		CPE				LLBMB			0INCENSE			WWBF			4	15	*3CPE-7LLBMB-0INCENSE-3WWBF*
		CPE				LLBMB						WWBF			3	42	*3CPE-7LLBMB-3WWBF*
		CPE				LLBMB		MYRRH							3	422	*3CPE-7LLBMB-9MYRRH*
		CPE				LLBMB		MYRRH				WWBF			4	22	*3CPE-7LLBMB-9MYRRH-3WWBF*
		CPE					HLBMB								2	14,918	*3CPE-8HLBMB*
		CPE					HLBMB					WWBF			3	14	*3CPE-8HLBMB-3WWBF*
		CPE					HLBMB					WWBF	AASA		4	12	*3CPE-8HLBMB-3WWBF-4AASA*
		CPE					HLBMB						AASA		3	1,279	*3CPE-8HLBMB-4AASA*
		CPE						MYRRH							2	847	*3CPE-9MYRRH*
		CPE						MYRRH				WWBF			3	49	*3CPE-9MYRRH-3WWBF*
			AGSLV							RF					2	5	*4AGSLV-RF*
			AGSLV							RF			AASA		3	1	*4AGSLV-RF-4AASA*
			AGSLV									WWBF			2	61,217	*4AGSLV-3WWBF*
			AGSLV									WWBF	AASA		3	35	*4AGSLV-3WWBF-4AASA*
			AGSLV									WWBF		BDPA	3	0.09	*4AGSLV-3WWBF-BDPA*
			AGSLV										AASA		2	76,153	*4AGSLV-4AASA*
			AGSLV		WLE										2	684	*4AGSLV-6WLE*
			AGSLV		WLE							WWBF			3	262	*4AGSLV-6WLE-3WWBF*
			AGSLV		WLE							WWBF	AASA		4	4	*4AGSLV-6WLE-3WWBF-4AASA*
			AGSLV		WLE								AASA		3	3,269	*4AGSLV-6WLE-4AASA*
			AGSLV		WLE	LLBMB									3	385	*4AGSLV-6WLE-7LLBMB*
			AGSLV		WLE	LLBMB						WWBF			4	12	*4AGSLV-6WLE-7LLBMB-3WWBF*
			AGSLV		WLE		HLBMB								3	34	*4AGSLV-6WLE-8HLBMB*
			AGSLV		WLE		HLBMB					WWBF			4	1	*4AGSLV-6WLE-8HLBMB-3WWBF*
			AGSLV		WLE		HLBMB					WWBF	AASA		5	19	*4AGSLV-6WLE-8HLBMB-3WWBF-4AASA*

			AGSLV		WLE		HLBMB						AASA		4	3,934	*4AGSLV-6WLE-8HLBMB-4AASA*
			AGSLV			LLBMB									2	316,384	*4AGSLV-7LLBMB*
			AGSLV			LLBMB					WWBF				3	5,787	*4AGSLV-7LLBMB-3WWBF*
			AGSLV				HLBMB								2	566,747	*4AGSLV-8HLBMB*
			AGSLV				HLBMB			RF					3	2	*4AGSLV-8HLBMB-RF*
			AGSLV				HLBMB					WWBF			3	3,253	*4AGSLV-8HLBMB-3WWBF*
			AGSLV				HLBMB					WWBF	AASA		4	497	*4AGSLV-8HLBMB-3WWBF-4AASA*
			AGSLV				HLBMB						AASA		3	193,341	*4AGSLV-8HLBMB-4AASA*
			AGSLV											BDPA	2	1	*4AGSLV-BDPA*
				SILVO								WWBF			2	1,070	*5SILVO-3WWBF*
				SILVO								WWBF	AASA		3	6	*5SILVO-3WWBF-4AASA*
				SILVO									AASA		2	22,516	*5SILVO-4AASA*
				SILVO		LLBMB									2	6	*5SILVO-7LLBMB*
				SILVO		LLBMB						WWBF			3	0	*5SILVO-7LLBMB-3WWBF*
				SILVO			HLBMB								2	115	*5SILVO-8HLBMB*
				SILVO			HLBMB					WWBF			3	9	*5SILVO-8HLBMB-3WWBF*
				SILVO			HLBMB					WWBF	AASA		4	50	*5SILVO-8HLBMB-3WWBF-4AASA*
				SILVO			HLBMB						AASA		3	30,206	*5SILVO-8HLBMB-4AASA*
					WLE					RF					2	2	*6WLE-RF*
					WLE					RF			AASA		3	1	*6WLE-RF-4AASA*
					WLE							WWBF			2	4,001	*6WLE-3WWBF*
					WLE							WWBF	AASA		3	2	*6WLE-3WWBF-4AASA*
					WLE								AASA		2	9,120	*6WLE-4AASA*
					WLE	LLBMB									2	91,222	*6WLE-7LLBMB*
					WLE	LLBMB						WWBF			3	709	*6WLE-7LLBMB-3WWBF*
					WLE		HLBMB								2	62,160	*6WLE-8HLBMB*
					WLE		HLBMB			RF					3	1	*6WLE-8HLBMB-RF*
					WLE		HLBMB					WWBF			3	179	*6WLE-8HLBMB-3WWBF*

					WLE		HLBMB					WWBF	AASA		4	55	*6WLE-8HLBMB-3WWBF-4AASA*
					WLE		HLBMB						AASA		3	12,708	*6WLE-8HLBMB-4AASA*
						LLBMB			0INCENSE						2	823,977	*7LLBMB-0INCENSE*
						LLBMB			0INCENSE			WWBF			3	10,596	*7LLBMB-0INCENSE-3WWBF*
						LLBMB					RIVN				2	16	*7LLBMB-2RIVN*
						LLBMB					RIVN	WWBF			3	13	*7LLBMB-2RIVN-3WWBF*
						LLBMB						WWBF			2	6,343	*7LLBMB-3WWBF*
						LLBMB		MYRRH							2	17,219	*7LLBMB-9MYRRH*
						LLBMB		MYRRH				WWBF			3	278	*7LLBMB-9MYRRH-3WWBF*
							HLBMB		0INCENSE						2	3	*8HLBMB-0INCENSE*
							HLBMB			RF					2	5	*8HLBMB-RF*
							HLBMB				RIVN				2	30	*8HLBMB-2RIVN*
							HLBMB				RIVN	WWBF			3	3	*8HLBMB-2RIVN-3WWBF*
							HLBMB					WWBF			2	3,140	*8HLBMB-3WWBF*
							HLBMB					WWBF	AASA		3	464	*8HLBMB-3WWBF-4AASA*
							HLBMB						AASA		2	101,586	*8HLBMB-4AASA*
								MYRRH				WWBF			2	965	*9MYRRH-3WWBF*
									0INCENSE			WWBF			2	13,547	*0INCENSE-3WWBF*
										RF		WWBF		BDPA	3	9	*RF-3WWBF-BDPA*
										RF			AASA		2	2	*RF-4AASA*
										RF				BDPA	2	130	*RF-BDPA*
											RIVN	WWBF			2	91	*2RIVN-3WWBF*
											RIVN	WWBF		BDPA	3	115	*2RIVN-3WWBF-BDPA*
											RIVN			BDPA	2	4,888	*2RIVN-BDPA*
												WWBF	AASA		2	70	*3WWBF-4AASA*
												WWBF		BDPA	2	213,436	*3WWBF-BDPA*
TOTAL															*92*	*6,430,716*	