Agroforestry for climate change adaptation and mitigation experience

Outline

1. **Introduction**

2. **AF for Climate Change adaptation**

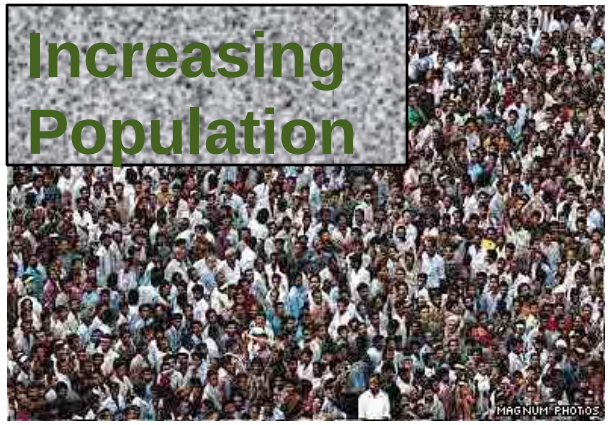
3. **AF for Climate mitigation**

1. Introduction

The overall CC impacts expected on agriculture are negative;

- **reduction in crop yields,**
- **increased land degradation,**
- **shifts in cropping zones**
- **the disappearance of some crops all together within particular altitudes because of temperature changes**

Climate Change : causes and impacts



1. Introduction

- Climate is an important factor of agricultural productivity, and at the same time agriculture is one of the main greenhouse gas sources, which is important to consider in terms of climate change.
- The agriculture sector both contributes to climate change, and will be affected by the changing climate.

1. Introduction

- Agriculture is also a major part of the climate problem. It currently generates 20-29%of total GHG emissions.
- Without action, that percentage could rise substantially as other sectors reduce their emissions.

1. Introduction----Climate Smart Agriculture

Climate smart agriculture with three main pillars:

1. sustainably increasing agricultural productivity and incomes;

2. adapting and building resilience to climate change;

3. reducing and/or removing greenhouse gases emissions, where possible.

1. Introduction---Climate inclusive development

- **Climate safe development**, i.e. development that leads to low vulnerability to climate change → **ADAPTATION**
- **Climate friendly development,** i.e. development that leads to low GHG emissions → **MITIGATION**

By integrating climate change into development projects and policies

2. AF and climate adaptation

Climate change adaptation refers to actions to reduce or eliminate the effect of climate change or take advantage of the positive effects

- Major climate change functions include:

  - reduce threats and enhance resilience

  - Allow species to migrate to more favorable conditions

AF adaptation functions

- Alter microclimate to reduce impacts of extreme weather events on crop production
- Alter microclimate to maintain quality and quantity forage production
- Alter microclimate to livestock stress
- Provide greater habitat diversity to support organisms (e.g. native pollinators and beneficial insects)

AF adaptation functions

- Provide structural and functional diversity maintain and protect natural resource services
- create diversified production opportunities to reduce risk under fluctuating climate
- Provide travel corridors for species migration

2.1. CC adaptation ----Agroforestry for enhancing food security

Agroforestry for food production
Agroforestry for incomes to support access to food
Agroforestry fuel wood
Agroforestry biodiversity conservation and environmental quality

Existing evidences indicated the positive effects of AF include:

- **increased productivity,**
- **improved soil fertility,**
- **efficient and balanced nutrient cycling,**
- **Conserve biodiversity**
- **Improved soil and water conservation management**
- **improvement of microclimate which are very important in the way of overall agroforestry health and its productivity**

2.1.Agroforestry for enhancing food security

- the yield and quality of production can be improved during cultivation
- Use of for many wild trees, including indigenous fruits,
- a two-fold yield improvement or more is possible through genetic selection
- bringing trees from the wild into cultivation it is essential to increase yield (Jamnadass et al. 2011).

2.2. Agroforestry for **incomes** to support access to food

- **The production of timber and other agroforestry tree products for markets also provide incomes for food purchase.**
- **Many trees are cultivated to provide medicines from bark, leaves, roots etc., which are sold to support incomes and are used for self treatment, supporting the health of communities along with the provision of healthy foods (Muriuki et al. 2012).**
- **native species from Ethiopia**

2.3. Agroforestry and fuel

- **Reduced access and increased prices of wood-based biomass have led to initiatives to promote agroforestry cultivation.**
- **Where smallholders practise agroforestry, less fuelwood needs to be purchased, there is less reliance on collecting from natural stands, and less time is involved in collection.**
- **This leaves more time for income-generating activities, especially for women who are usually the major fuelwood collectors**

2.3. Agroforestry and fuel

- **Access to cooking fuel provides people with more flexibility in what they can eat, including foods with better nutritional profiles that require more energy to cook.**

- **The cultivation of woodlots allows the production of wood that is less harmful when burnt and has higher energy content.**

2.3. Agroforestry Vs biodiversity

- Diversity and food security varies in different:
- Agroecology
- agroforestry systems and technologies

2.3.Ethiopian e.g. – role biodiversity in AF

Agroforestry type	No. crop species	No. woody species	Animal type
Apple-Bamboo based Highland	13	14	5
Fruit-coffee-enset based midland	19	29	6
Moringa based lowland	13	19	5

2.3. biodiversity- Food availability and daily dietary mix – Highland

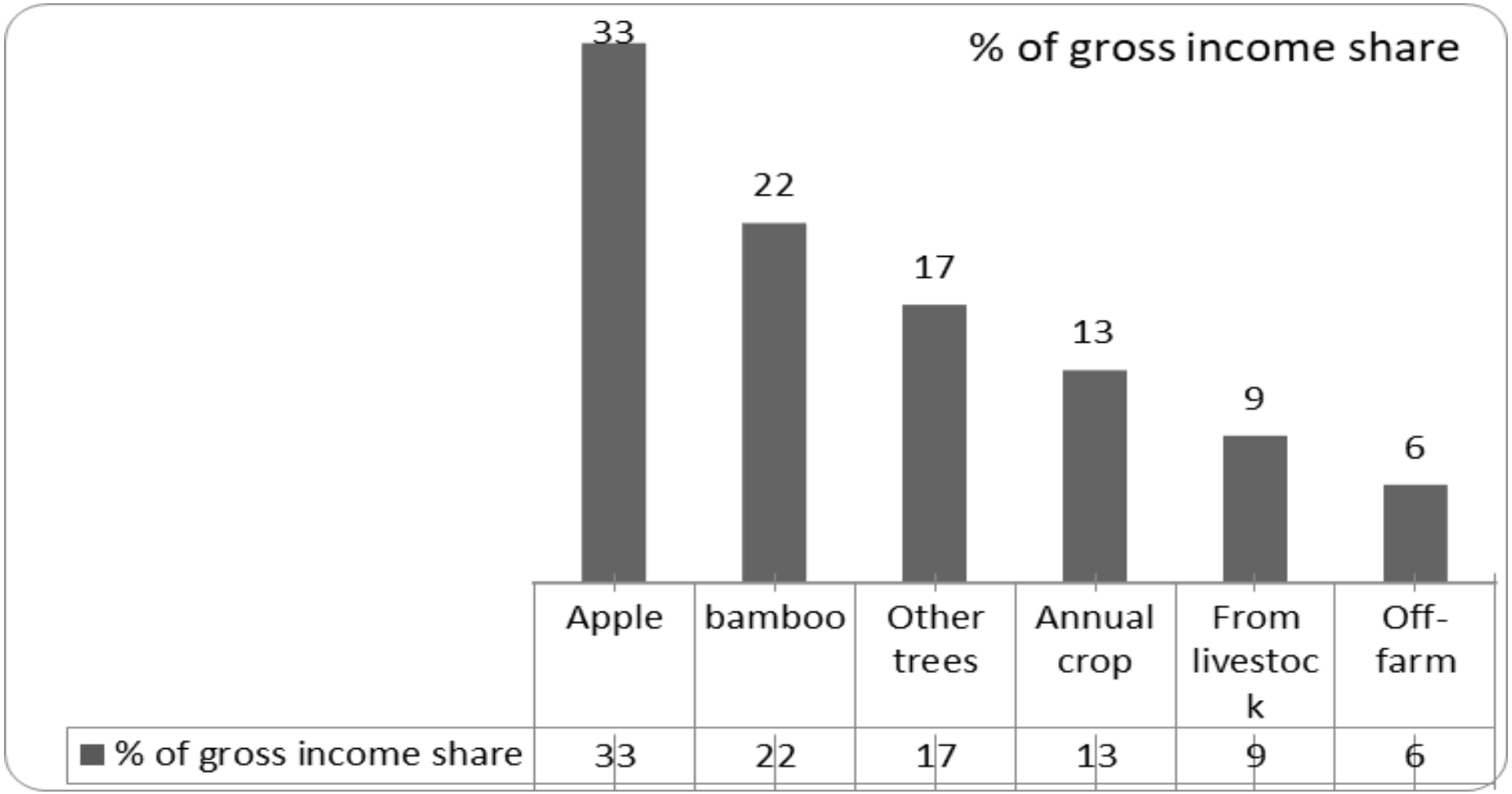
Annual crops intercropped with apple	practitioner households n=94
Ethiopian kale	85(90.42%)
Carrot	49(52%)
Onion	47(50%)
Garlic	59(62.70%)
Leeks	37(39.40%)
beet roots	44(47%)
red pepper	91(96%)

Biodiversity- Contribution to Income diversification

In terms of income diversification, interviewed farmers at Teticha got annual income from ten species with seasonal distribution of 5, 5, 5 and 4 species

Apple is the major sources of income with highest (33%) share at Teticha.

Biodiversity Vs **income** --- **highland**



Biodiversity- Contribution to Energy -- highland

Woody species grown in the AF are used as major source fuel wood.

About 99% of practitioners harvest their fire wood from their own agroforestry farms

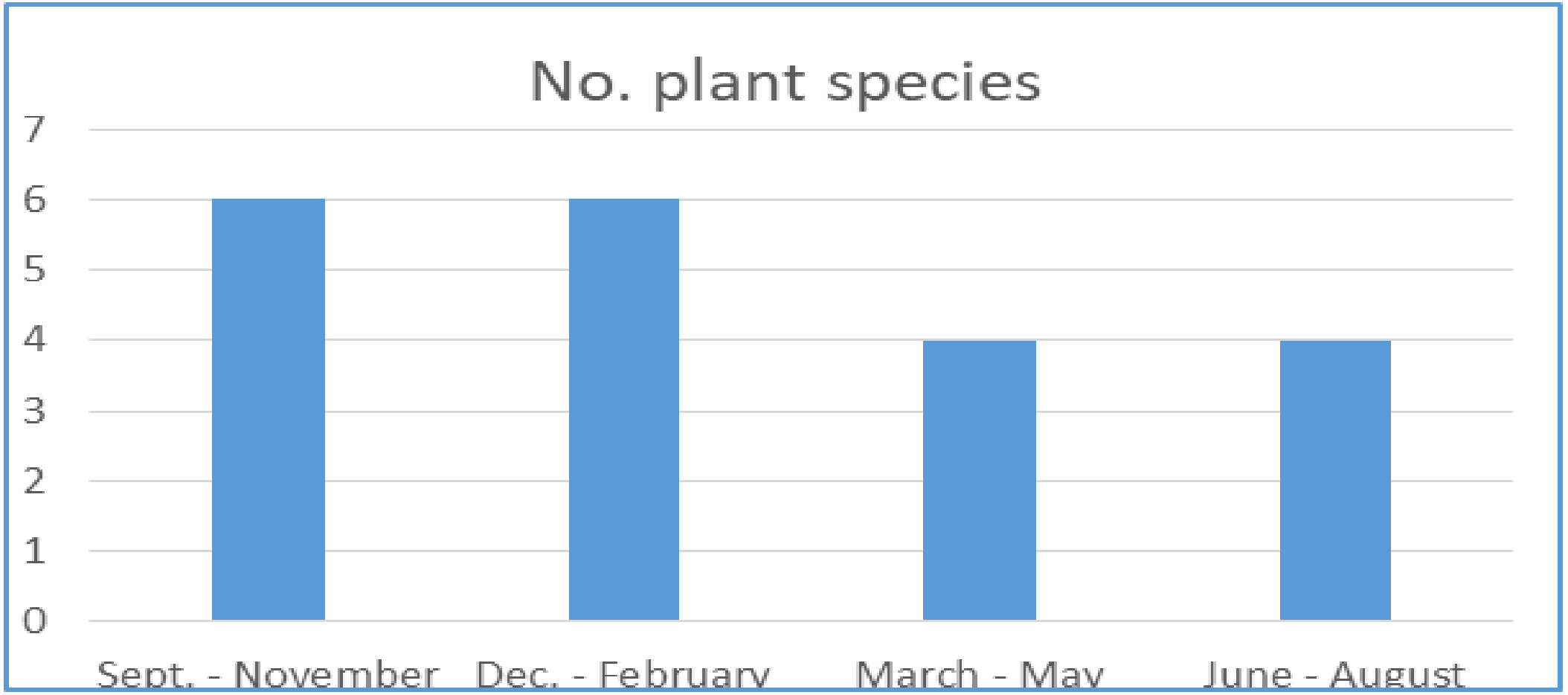
Never use animal dung for fuel

Types of energy used by both practitioners Teticha Kebele

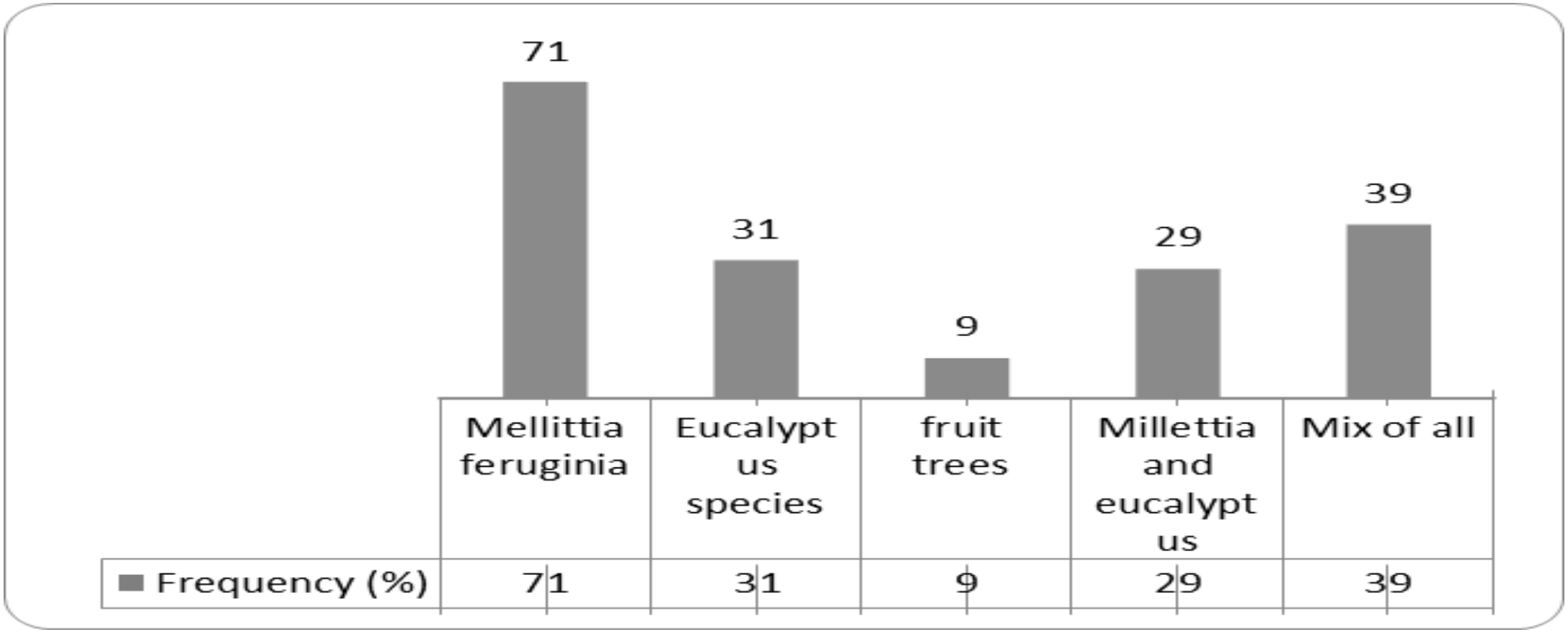
Biodiversity- Income diversification midland Chichu

Component	No HHs	income Birr	Duration
Coffee	116	23847 (45)	October to December
Enset	22	1284(2)	Year round
Banana	115	5983(11)	Year round
Mango	122	5198(10)	April
Avocado	120	13500 (26)	February & June
livestock	60	2325(4)	When required
Maize	10	510 (1)	When required

2.1. biodiversity- Income diversification midland



Biodiversity- Contribution to Energy



Biodiversity- Income diversification -- lowland

- At Gocha at least **six species are used as main source** of income indicating that role of agroforestry for income diversification and livelihood improvement,
- Coffee, *M. stenopetal*, Catha, Mango, *Terminalia brownii*, Lemon, *cassava* and animal sale are the major sources of income.
- The net benefit, 25,466.01 ETB, of moringa based agroforestry practice was **three fold higher than the net profit, 7,895.93 ETB, of monocropping system.**

2.4.Agroforestry ecosystem services

- **Agroforestry trees provide important ecosystem services including:**
- **soil, spring, stream and watershed protection;**
- **animal and plant biodiversity conservation;**

2.1.4.Agroforestry ecosystem services, climate change

- **An advantage of smallholder agroforestry systems is that they can perform wider services while directly supporting local production**
- **Appropriate combinations of crops, animals and trees in agroforestry systems can not only increase farm yields, but promote ecological and social resilience to change because the various components of a system and the interactions between them will respond in differing ways to disturbances.**

2.1.4.Agroforestry ecosystem services, climate change

- A diversity of species and functions within integrated production systems is therefore a risk reduction strategy,

- agroforestry is recognised as an important component in climate-smart agriculture for both its adaptation and mitigation roles (Neufeldt et al. 2012).

- For example, soil fertility improvement technologies can stabilise crop yields in drought conditions.

Soil properties under AF Chichu –**midland**

Soil properties	homegarden	Village garden	forest	maize field
OC %	2.97a	2.7la		1.76b
TN %	0.28a	0.26a		0.20b
P(PPM)	23.91a	10.45b		8.7b
P^H	6.25a	6.0a		5.65a
K	4.96a	6.9a		2.19b

Contribution to watershed management-midland Chichu --- midland

Chichu Dilla AF only through agroforestry from1976 -2006 year increase by 12 % currently covering 72% land cover of Gedeo

The Moringa Based in Konsso is known for physical structures

AF Integrated Watershed Management – **midland**

Non-Integrated Watershed Management (Boroda area **Midland**)

The Moringa Based watershed in Konsso is known for physical structures - **Lowland**

3. AF role in climate change mitigation activities

- AF mitigation is activities that reduce GHG emissions in atmosphere or enhance the storage GHGs store in ecosystem:

  - Sequester carbon

  - reduce GHGs emissions

3. AF function that support CC mitigation

Sequestration accumulate:

- C in woody biomass and
- C in the soils

3. AF function reduce GHG emissions

A. reduce fossil fuel consumption

- Reduce equipment runs with trees
- Reduce farmstead heating and cooling

B. reduce carbon dioxide from farmstead structures

3. AF function reduce GHG emissions

C. reduce nitrous oxide emission

- By greater nutrient uptake through plant diversity
- By reducing nitrogen fertilizer application in tree components

D. enhance forage quality thereby reduce methane emission

3. Agroforestry for climate change mitigation

- agroforestry systems have 3–4 times more biomass than traditional treeless cropping systems (Smith P et al., 2012),

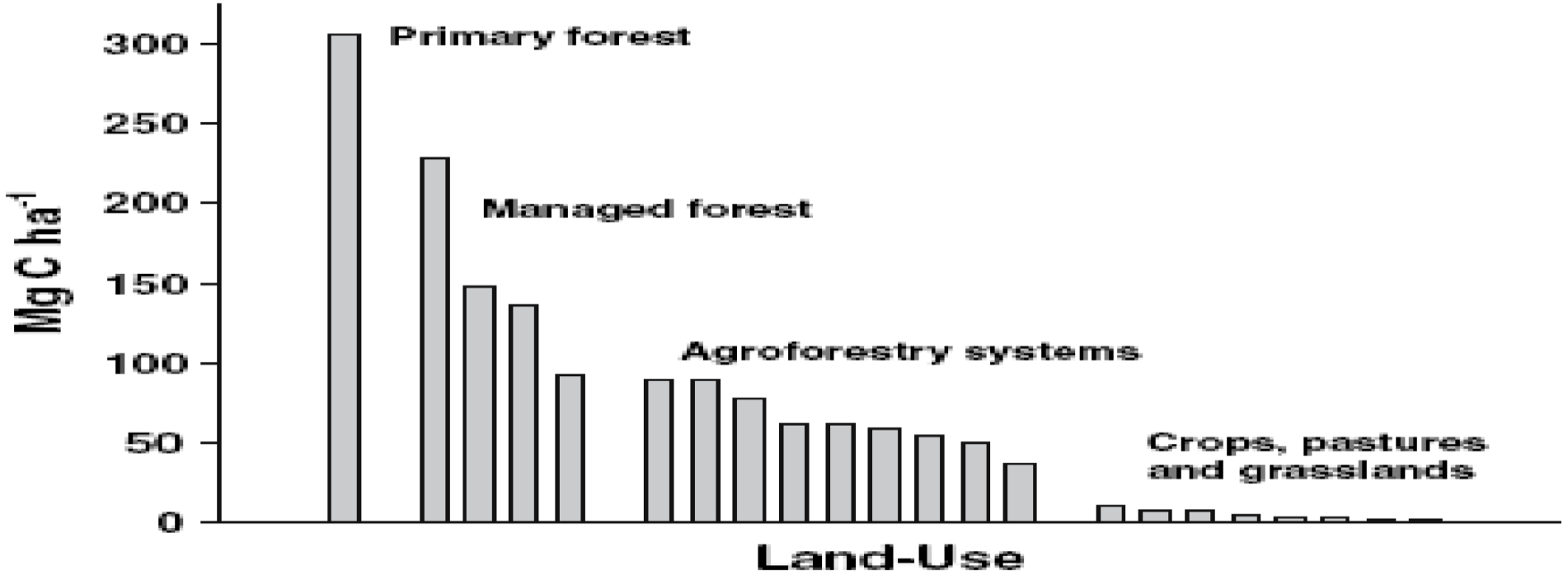
- in Africa they constitute the third largest carbon sink after primary forests and long term fallows (Oke DO and Odebiyi KA 2007).

3. Agroforestry for climate change mitigation

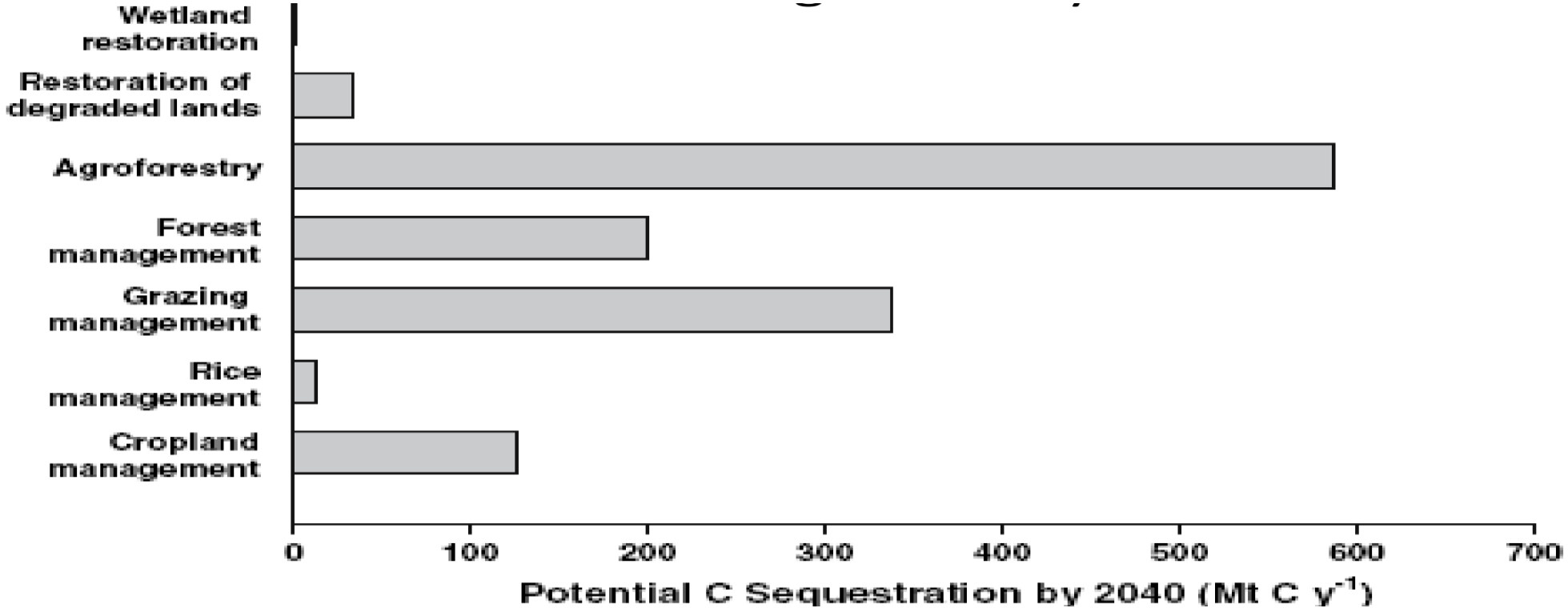
the world stores an estimated 45.3 PgC (45.3 billion tonnes) in above- and below-ground biomass carbon on agricultural land, with trees contributing **> 75% (34.2 PgC)** Zomer et al. (2016).

According the same authors, from a total agricultural land area 435,230 km^2 in Ethiopia, a total 584 in 2000 and 564 in 2010 million ton C biomass carbon is stored which is equivalent to **13.4 and 13 t C ha^{-1}, respectively, of which trees contribute more than 61 %**

Carbon stock at maturity of different ecosystems in humid tropic. Verchot et al. Mitig Adapt strat Glob Change (2007) 12:901-918



Agroforestry has a high carbon sequestration potential on the long term (by the year 2040) not because it has a high carbon density(compared to forests) but because a lot of lands can potentially beturned into agroforestry (IPCC, 2000)



Carbon stock in various agroforests in southern Ethiopia

Agroforestry type	Biomass Carbon type	Mg ha^{-1} MM	Reference
Gedeo agroforest	Agroforest + soil C	95.78	Fikere (2011)
	Agroforest + soil C	78-115	Mesele (2013)
	Native coffee forest	230	Mohammed (2011)
South west (Jima)	Coffee based Agroforest	150	
	Annual crop fields soil C	65	
From Sidama	Natural patch forest	334.86	Abiot Mola (2012)
	Coffee-Enset based AF	242.02	
South west (Kafa)	Natural forest	393.91	Solomon Estifanos (2013)
	Semi-NF with coffee	446.08	
	Homegaden	218.84	

Carbon stock in urban agroforestry

Aboveground carbon stock (AGC) of all woody species in Dilla 62.205Mg /ha (228.085 ton CO_2equi./ha).

Fruits stored the highest AGC of 31.36 Mg ha^{-1}

Provisional result of ongoing research project on carbon stock in different green infrastructures of Hawassa city Southern Ethiopia

Various estimations of C sequestration potential in the tropics have given different figures

- **tropical agroforestry systems have C sequestration potential ranging between 12 and 228 Mg C ha-1 with a median value of 95 Mg C ha-1 (Albrecht and Kandji (2003))**
- **In humid areas, agroforestry systems can sequester up to 50 Mg C ha-1, and smallholder agroforestry in the tropics can sequester between 1.5 and 3.5 Mg C ha-1 year-1 (Montagnini and Nair 2004).**

3. Agroforestry for climate change mitigation

- Total C stocks in coffee agroforestry systems amounted to 127±6.6 (SE) (SE) Mg C ha-1 in the western highlands of Guatemala (Schmitt-Harsh et al. 2012) and
- Coffee agroforestry systems in the central valley of Costa Rica 93 ±7.75 (SE) Mg C ha-1 (Hager 2012).

Thank for your attention!