

Assessment of Agricultural Potentials and Constraints of Natural Resources Management for Research Implementation in Gedeo Zone South Ethiopia Region

Markos Habtewold^{1*}, Temesgen Geburie¹, Nadew Boto¹

Abstract

This study aimed at assessing agricultural potentials and constraints of natural resources management for research implementation in Gedeo zone south Ethiopia Region. The result indicates that the use of organic and inorganic fertilizers was not efficient and the crop yield was decreasing from year to year. Use of organic fertilizer is for only high value crops of enset and coffee without determined rate. Farmers were not practiced organic fertilizers like Vermi-composting and bio-fertilizer application as a new technology. As the study result indicates irrigation water management practices were very limited. Some of farmers were using irrigation through traditional method without crop water requirement and scheduling for the crop. There was opportunity of shallow well water at household level. However, farmers were not practiced that water opportunities as an alternative water source for irrigated garden crops. More of the area was covered with enset and coffee-based agroforestry. But due population expansion; the system was decreased and farmers were deforesting natural forests mainly for house construction and income generations. Community farmers were conserving their soil and water through planting trees rather than using other physical and biological soil water conservation practices. Therefore, this study was conducted to identify agricultural potentials and limitations of natural resource management for research implementations.

Keywords: Natural resources management, opportunities, constraints, baseline survey, research

INTRODUCTION

Natural resources are basis for all living things on our planet, while after the introduction of agricultural interaction of human and nature have adversely changed [1]. Soils have physical, chemical, and biological attributes which contribute to soil health and subsequent productivity of agriculture [2]. In response to human population increase over time, fragmentation of farmlands has become acute leading to deterioration of soil fertility and decline in the productivity of crops and livestock. Consequent to this, farmers have started to cultivate steep slopes and communal grazing lands, cleared

forests and threatened biodiversity. On the other hand, ecologically less friendly *Eucalyptus spp.* has been replacing indigenous trees and expanding at alarming rates for its use as construction material and fuel energy [3]. The implementation of key principles and practices in water management is essential for achieving sustainability [4]. There were opportunities of nearby rivers for irrigation where conventional irrigation practices utilized traditionally but there is no modern irrigation schemes in their area. Though there are rivers suitable for irrigation scheme nobody is interested to install the modern irrigation scheme [5]. Well-managed natural resources generate flows of

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benefits that provide the basis for maintaining and improving livelihoods, improve the quality of life, and contribute to sustainable growth [6]. Knowledge and skills to harness irrigation potentials; inadequate use of irrigation technologies; and limited use of physical soil and water conservation practices. Therefore, this conducted to identify both the potential opportunities constraints for agricultural research interventions.

MATERIALS AND METHODS

Description of Study Area

The study was conducted in Food System Resilience Program (FSRP) target areas of purposively selected districts of Gedeb, Choriso and Bule districts in Gedeo Zone South Ethiopia Region. Gedeo zone is found at 369 km and 90 km from Addis Ababa and Hawassa respectively along the main road of Addis Ababa to Moyale [7]. Geographically, it is located at 6°10'0" to 6°30'0"N and 38°10'0" to 38°30'0" E presented in Figure 1 below. Agro ecologically of the zone comprises 26% Dega (highland with altitude range 2500–3200 m. a. s. l), 65% Woina Dega (midland with altitude range 1750–2500 m. a. s. l), and 9% Kola (lowland with altitude range <1750 m. a. s. l).

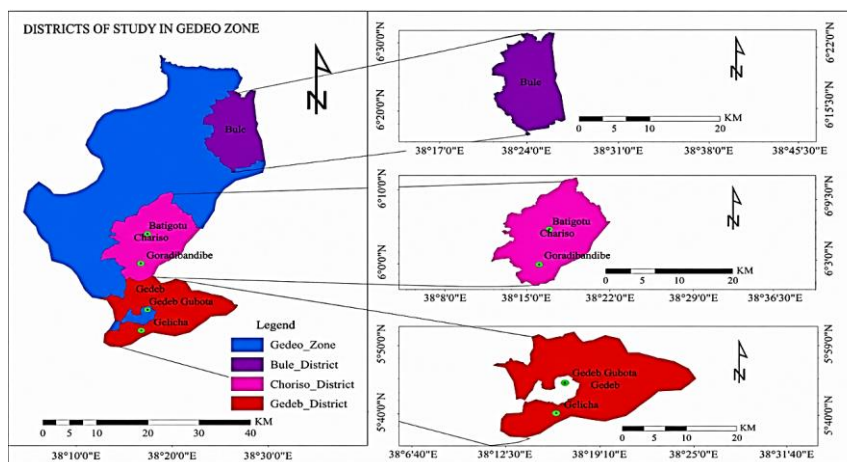


Figure 1. Map of study area.

Table 1. Average meteorological data of the study area

Month	Min temp (°C)	Max temp(°C)	Humidity (%)	Wind (km/day)	Sun (hours)	Rad (MJ/m/day)	Eto (mm/day)
January	7.3	26.6	62	130	8.4	20.5	4.07
February	9.8	26.3	60	130	8	21	4.25
March	10.9	26.9	65	147	7.3	20.8	4.39
April	11.3	25.2	75	130	7.4	20.9	4.05
May	11.2	24.1	77	130	7.2	19.8	3.75
June	11.8	23.6	80	156	6.7	18.6	3.5
July	11.8	23.3	80	121	4.7	15.9	3.1
August	11.9	23.3	77	121	5	16.8	3.3
September	11.3	23.4	81	86	6	18.6	3.44
October	11.4	23.1	71	78	7.1	19.7	3.6
November	8.9	24.7	70	95	8.5	20.9	3.79
December	6.3	26.1	58	112	8.2	19.7	3.87
Average	10.3	24.7	71	120	7	19.4	3.76

Meteorological Data of the Study Area

The high humidity levels lead to the development of dense, towering cumulonimbus clouds, which are often associated with thunderstorms and heavy precipitation. High humidity is a key ingredient for precipitation formations. The average temperature of the area ranges from 10.3-24.7°C which is suitable agricultural production presented in Table 1 below.

The average maximum rain fall had occurred in September, April, May and October respectively in Table 2 below. As Figure 2 indicates that the extent of rain decreases from November to February. In these months farmers may use fully irrigation for crop production.

Questionnaires

Primarily categorized questionnaires most probably like open-ended type that was used for the study. Open-ended questionnaires provide deep, qualitative insights in respondents' own words, offering context, motivations, and unexpected themes for the assessment.

Table 2. Average rainfall data of the project area

Months	Rain (mm)	Effective rain (mm)
January	29	27.7
February	42	39.2
March	123	98.8
April	293	154.3
May	296	154.6
June	136	106.4
July	101	84.7
August	124	99.4
September	243	148.5
October	301	155.1
November	103	86
December	13	12.7
Total	1804	1167.4

Graphical representation of meteorological data

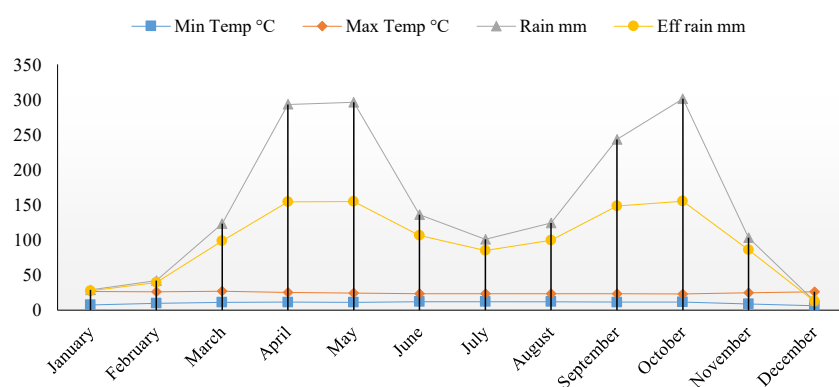


Figure 2. Graphical representation of meteorological data.

RESULTS AND DISCUSSIONS

Purposively selected farmers through designed open-ended questions. Orientation and the way forward for the study were given before commencing the questionnaires. Researchers from departments of crop science, livestock, natural resources, and agricultural economics were assigned based on their specialization for the baseline survey. The selected kebele respondents were divided into questionnaires as shown in Figure 3 below.

Table 3. General information about specific districts.

Description	Area (ha)	
	Gedeb district	Choriso district
Land use land cover (LULC)		
Cultivated land	21,846.25	13225.73
Irrigated land	76.72	-
Grazing land	235.5	315.58
Forest	147.16	863.29
Degraded land	58.9	
Settlement	1912.6	
Others	171.46	
Climate		
Rainfall	1167.4-1804mm	1167.4-1804mm
Temperature max	24.7°C	24.7°C
Temperature min	10.3°C	10.3°C
Humidity	72%	72%
Agro ecology	High land	High-mid land
Dominating soil type	Clay loam	Silt soil
Average land holding size	0.5	
Organic and bio-fertilizer		
Compost + FMY	379,801.9m ³ (625ha)	16,213.7m ³
Vermicomposting	175m ³ (3.5ha)	-
Bio-slurry	-	-
Bio-fertilizer	-	-



Figure 3. Focus group discussion with purposively selected farmers.

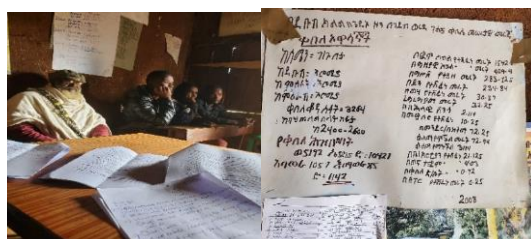


Figure 4. Secondary survey data collection from office.

All necessary agricultural baseline data was collected from kebele experts, local elders and office written documents. According to the study; Gedeb gelicha kebele information indicates that perennial crops 1542.81 ha, short season crops 909.9 ha, grazing land 283.125 ha, forest land 234.84 ha, water body 30.37 ha, swampy land 32.25 ha, traditional forum 2.114 ha, graves land 10.25 ha, local town 72.25 ha, to be used for development land 72.94 ha, not to be used for development land 3.114 ha, religion covered land 21.125 ha, health centres 4.03 ha, kebele bureaus 0.72 ha and FTCs 0.25 ha as shown in Figure 4 below.

Common natural resources available in the area were water (surface and ground water), forest (natural, plantations and agro forestry), and cultivable, communal and private grazing lands. The major cereal crops in the area were maize, wheat and barley sown with inorganic fertilizer. Whereas enset, coffee and some garden crops are other major potential cash crops grown with organic fertilizers.

Soil Fertility and Health Management

Soil fertility refers to the soil's ability to supply crop nutrients in the right quantities and qualities over a sustained period. The dominant soil type in the area was loam soil with a black colour (xiloka butina) in local languages followed by red soil (demo butena locally) that identified during focus group discussion (FDG). Soil pH value of area ranges from strongly acidic to neutral and it was salt free [8].

Fertilizer Application and Its Rate

Farmers have practiced on use of inorganic and organic fertilizer for major crops in this study area. Commonly farmers use 100kg/ha NPS and 100kg/ha urea as blanket recommendation for major crops of maize, wheat, barley and farmers use compost and farmyard manure as organic fertilizers for coffee, enset and for vegetable crops like carrot, head cabbage, beat root, habesha gomen etc. Application time, and method is different from farmer to farmer but full dose of NPS and $\frac{1}{2}$ of urea at planting followed by $\frac{1}{2}$ urea after 45 days of planting by broadcast and band application is common practice. Spot application of compost and Farmyard manure before planting time is usual practice for coffee and Inset in the area.

Limitations of Soil Fertility and Health Management

- The district's soil was not lab tested to whether it has acidic, or other limitations.
- Continuous farming system due to piece land per household for fallowing and crop rotation declines the soil fertility and the yield from year to year.
- Organic fertilizer is used for only high value crops of enset, coffee and same garden crops without recommended rate on hectare base.
- Knowledge gap in compost and FMY preparation
- Inorganic fertilizer is used for only cereal crops maize, wheat and barley.
- Vermicomposting is not known and farmers have an interest in using technology.
- Farmers mentioned that there is acidity problem and they use lime only time that gained from agricultural office of district.
- Farmers were interested in using bio-fertilizer for legume crops. But its availability and accessibility are very low.

Irrigation Water Management

There were opportunities of nearby rivers for irrigation where conventional irrigation practices utilized traditionally but there is no modern irrigation schemes in their area. There were only three modern functional irrigation schemes in both Gedeb and Chariso districts. Some of the farmers were using shallow well ground water for home garden crops in household level in especially in Gedeb district. Community farmers were highly interested on using micro irrigation technologies on garden irrigable crop production for income generation. There were irrigation schemes in which farmers were practicing irrigating wheat and other vegetable crops in Choriso district. But management practice was very poor and crop water requirement and irrigation scheduling was not applied as shown in Figure 5 below.

Constraints of Using Irrigation Technologies

- Limited number of modern irrigation schemes with appropriate gates
- Most of irrigation schemes were traditional without appropriate gates
- Some farmers were practicing micro irrigation for garden crops in minimum coverage
- No available seed sources (carrot, beat root, garlic, lettuce, and head cabbage)
- Gap of crop-based irrigation scheduling
- Training gaps in irrigated agriculture as capacity building
- Water harvesting technology is not common practice as an alternative water sources

Forestry Lands

Forestry is practiced in plantations and natural stands of agroforestry, it utilizes multilayer cultivation with large trees sheltering indigenous enset, the main food crop, under which coffee grown and other shrubs. More than ninety percent of the land area of Gedeo Zone is covered in agroforestry, with enset and coffee based main agricultural products [9]. Cultural knowledge for how to manage and conserve the agroforestry system stems from the customs and beliefs of the Gedeo people, leading to a mutualistic human-environmental relationship [10].



Figure 5. Head work and motor pump irrigation scheme in Batigotu kebele.

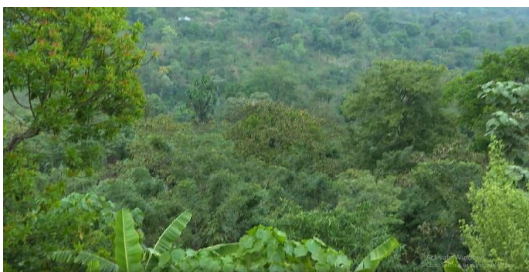


Figure 6. Forestry performance of study area.

Natural Forests

As the study indicates, the major natural forest species found in both Gedeb and Choriso districts were *Syzygium guineense* (dokima), *Milicia ferguina* (xa'rato/ Birbira), *Croton macrostachys* (bisana), *Ficus species* (shola), *Podocarpus falcatus* (zigiba), *Cordia Africana* (waniza), *Prunes Africana* (tikuri encheti).

Plantation Forests

Generally, plantation trees have been established through planting or seeding by human intervention. The major dominant tree species existing in plantation forest species are Eucalyptus (behirzafi), *Juniperus procera* (tid), *Pines pachula* (shiwashiwe), wanza, etc.

Agro Forestry

The dominant types of agro forestry system in the area were home garden, coffee based and scattered tree systems. The major tree species recommended for agro forestry in the area were coffee, avocado, mango, gishita, apple, orange, lemon, korich, ficus species (shola) and cordia Africana (waniza), *Milicia ferguina* (birbira), and *Croton macrostachys* (bisana). All agro ecology of the zone covered with full of natural forest and farmers cut and use the tree through permission and community rule and regulation. They must plant three trees before cutting one tree which is rule of Gedeo community at all. Community farmers were planting Eucalyptus (Behirzafi), Juniper (tid) tree from time to time as a plantation forest.

Limitations of Natural, Plantation and Agro Forestry

- Deforestation of forests resources for house constructions and income source generations
- Farmers were planting eucalyptus tree for house construction and income generations
- Some farmers were planting agro forestry trees without recommended plant spacing
- Endangered indigenous tree species are *Syzygium guineense*, *Podocarpus falcatus*, *Hygenia abyssinica*
- Endangered non-timber forest product like bamboo disease which damages the roots and the leaf.
- Regeneration status in the area is limited due to low afforestation
- The population size is beyond the carrying capacity of the system, creating an imbalance between consumption and maintenance.
- The stimulant plant, khat (*Catha edulis*) is expanding at the expense of dominant crops such as enset and coffee.
- Lack of nursery sites specially for coffee and other species

Soil and Water Conservation Practices

Gedeo zone is especially known with soil water conservation practise in planting trees. As usually known that vegetation, including trees, holds soil in place and shelters it from wind and water, preventing soil erosion. The other practices like vegetation lessens the impact of precipitation that hits the ground, shelters and the soil from wind erosion as well. As the survey result indicates that there was degraded land/bare land at Banti menderi in Gora dibandibe kebele.

Limitations of Soil and Water Conservation Practices

- Limited number of physical soil and water conservation practice.
- Biological, or integrated SWC practices like grass strip (elephant grass (*Pennisetum purpureum*), *Sesbania* (*Sesbania sesban*), desho grasses) were very limited in the districts.
- Area closure technologies were not practiced rehabilitating degraded lands
- Awareness gap on adoption of soil and water conservation practices

CONCLUSIONS AND RECOMMENDATIONS

There was blessed natural resource gifts as a Gedeo zone to conduct any agricultural research projects in the districts. However, there was so many research intervention gaps observed that on all natural resource management practices. The type of soil and its characteristics was not scientifically known,

and organic fertilizer is used for only high value crops of enset and coffee. Other soil fertility management technologies like vermicomposting, bio-fertilizer (*rhizobium* strain), and bio-slurry were totally not practiced and its rate is not known.

Both river and ground water sources are good opportunity for irrigation, and some farmers were practicing using irrigation. But irrigable crop varieties, irrigation scheduling, and crop water requirement was not identified. There was high potential of shallow well water sources at household level for irrigable garden crops production as an alternate sources. Generally modern irrigation schemes were very limited in number in the districts to manage irrigation water distribution losses and conflicts due to irrigation water competition. The full of natural, plantation and agro-forestry system practices. But some farmers were deforesting all natural and plantation forests for house construction and income source generations. Plantation forest especially eucalyptus tree decreases the soil fertility from time to time which in turn decreases the yield of the crops. Soil and water conservation was practiced only in planting tree method rather than physical and biological conservation methods. There were limited soil physical and biological conservation practices in the area which may need research intervention.

Therefore, natural resource management research recommendations should be: - Integration of organic and inorganic soil fertility improvement strategies should be launched. Irrigation water management practices through crop water requirement and irrigation scheduling should be determined. Micro-irrigation practices from shallow well for different home garden crops at household level and alternative water harvesting technologies should be introduced and demonstrated. Agro-forestry and plantation forestry practices should be intensified and supported by research scientifically. Trainings on soil fertility, agricultural water, and forestry and soil water conservation management practices should be periodically given to fill gaps of natural resource management.

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Author Contributions

Markos Habtewold contributed to survey data collection, writing full write up and finalizing, Temesgen Gebure, contributed to collection field data and writing first draft and Nadew Boto is a focal person, who contributed data collection, coordination, and logistics facilitation.

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Declarations

Conflict of interest: There are no conflicts of interest among authors.

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Annexes

PART I. Check List for Key Informant on Natural Resource Management Production

1. What is the proportionate significance (area coverage) of cultivated land, grazing land (communal, own/private), forest land (natural, plantation, agro-forestry), bare/degraded land and others (specify) in your area and how do you manage them or what are the best management practices?
2. Is there recommended fertilizer types (inorganic, organic and bio-fertilizers) and rates (blanket or recommended) for the major crops grown in the area?
3. What are the organic (compost, vermin-compost, farm yard manure) and the extent of bio-fertilizer use in your area?
4. What are soil related constraints in your area (soil fertility decline, organic matter decline, acidity, salinity, waterlogging, soil erosion, etc.), extents of the constraints (area coverage) and what are the management options?
5. If you use lime for soil acidity stress reclamation, what are the sources of lime and what is the rate of application in your area?
6. How do you drain excess water from vertisol farmlands (community base, household level, landscape level) and how you manage conflicts raised due to the flow of drained water from farms to farms?
7. What are the sources of irrigation water in your area and is there any conflict on the use of irrigation water?
8. If there is conflict on the use of irrigation water, how do you manage?
9. Do you monitor the quality of irrigation water and, if so, how often and by what method do you monitor irrigation water quality?
10. Do you monitor or quantify effectiveness of soil and water conservation measures? -
11. Do you perceive climate change in your area and, if so, what are the indicators and causes of climate change?
12. If climate change is evident in your area, what are the effects of climate change and how do you mitigate the effects?
13. What are the challenges related to fertilizer use, land use (cultivation land, grazing land, forest land, bare land, etc.) and what are the challenges of land management options?

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Part II**Land Use/Land Cover:**

1. What is the proportion of communal and private grazing land in your area?
2. What are challenges related to communal and private grazing land in your area?
3. How do you manage the challenges related to communal and private grazing land?
4. Do you think that your management is best practice and can be adopted to other areas?

Bare Land/Degraded Land:

1. What is the proportion of bare land/degraded land in your area?
2. What are challenges related to bare land/degraded land in your area?
3. How do you manage the challenges related to bare/degraded land (area closure, multipurpose tree plantation, land management like physical and biological structures, etc.) in your area?
4. Do you think that your management is best practice and can be adopted to other areas?

Forest Land:

1. What are the major tree species existing in the natural forest in your area?
2. What are challenges related to natural forest in your area?
3. How do you manage the challenges related to natural forest in your area?
4. Do you think that your management is best practice and can be adopted to other areas?

Plantation Forest:

1. What are the major tree species existing in the plantation forest in your area?
2. What are challenges related to plantation forest in your area?
3. How do you manage the challenges related to plantation forest in your area?
4. Do you think that your management is best practice and can be adopted to other areas?

Agro-Forestry:

1. What is the dominant type of agro-forestry system in your area (home garden, wood lot, coffee farms, hedge plantation, boundary plantation, scattered trees)?
2. What are the major tree species recommended for agro-forestry in your area?
3. What are challenges related to agro-forestry system in your area?
4. How do you manage the challenges related to agro-forestry system in your area?
5. Do you think that your management is best practice and can be adopted to other areas?

Soil Fertility and Health Management:

1. What are the dominant soil types in your area (local names, colour, etc)? -
2. What are the limitations of the dominant soil types in your area? -
3. How do you evaluate the fertility status of the dominant soil types in your area? -
4. If the fertility status is poor, do you apply inorganic/organic fertilizers and, if so, what types of fertilizers?
5. If you apply inorganic/organic fertilizers, to which major crops do you apply?
6. What is the rate of inorganic/organic fertilizer application to the major crops grown in the area?
7. What are the methods (broad casting, spot application, band application, foliar) and time of inorganic/organic fertilizers application to the major crops grown in the area?
8. What are the challenges in using both inorganic and organic fertilizers?
9. Do you use bio-fertilizers for legumes?
10. If your answer to 'i' above is yes, what is the source of the bio-fertilizers? -
11. If you do not use bio-fertilizers, why?
12. What are the challenges in using bio-fertilizers?

Soil Acidity Stress Management:

1. Is there soil acidity stress problem in your area?
2. If there is soil acidity stress problem, what are the indications for the presence of the problem and how do you manage it (lime, organic sources, tolerant crops/crop varieties, etc.)?

3. If you use lime as a remedial measure against soil acidity problem, where do you get the lime from?
4. What is the rate of lime application, if any?
5. What is the method of lime application, if any?
6. What is the time of lime application, if any?
7. What are the challenges in using lime, if any?

Soil Salinity Management:

1. Is there soil salinity stress problem in your area? -
2. If there is soil salinity stress problem, what are the indications for the presence of the problem and how do you manage it (leaching, tolerant crops/crop varieties, gypsum, etc.)?
3. If you use leaching as a remedial measure against soil salinity problem, how do you know the leaching requirement?
4. What is the rate of gypsum application, if any?
5. What is the method of gypsum application, if any?
6. What is the time of gypsum application, if any? -
7. What are the challenges in using gypsum, if any?

Vertisols Management:

1. Are Vertisols the dominant soil type in your area? -
2. If Vertisols are the dominant soil type, how do you manage waterlogging problem (BBF, shurubie, traditional drainage, early planting, use of waterlogging tolerant varieties, fertilizers, etc.)?
3. If Vertisols are the dominant soil type, which crops or crop varieties are grown on vertisols, if any?
4. If Vertisols are the dominant soil type, what is the cropping system you use on vertisols? -
5. If Vertisols are the dominant soil type, what types and rates of fertilizers you use for the major crops grown on vertisols? -
6. What are the challenges in vertisols management?

Soil Erosion:

1. Is soil erosion a dominant problem in your area?
2. If soil erosion a dominant problem, what types of erosion are prevailing in your area (sheet, rill, gully)?
3. If soil erosion a dominant problem, what are the causes (deforestation, high rainfall, poor farming practices) and the effects?
4. If soil erosion a dominant problem in your area, how do you manage (cultural practices, physical structures, biological measures, integrated methods, etc.)
5. If you use any of the erosion control measures mentioned above, what are the advantages and disadvantages of each measure?
6. What are the challenges in managing soil erosion? –

Water Management:

1. Is irrigation a common practice in your area and is there an efficient irrigation scheme to meet demand of the community in your area?
2. If irrigation is a common practice, what are the sources of water for irrigation (water harvesting, rivers, ground water, and lake)?
3. If irrigation is a common practice, what method of irrigation do you use (flood, furrow, drip, sprinkler) and what kind of furrow irrigation method (conventional, alternate, fixed-alternate) do you use if, in case, furrow irrigation is the dominant method?
4. If irrigation is a common practice, what is the hectares of the irrigated area and what are the irrigated crops you grow?
5. If irrigation is a common practice, for which cropping system do you use irrigation (mono-cropping, multiple-cropping)? -

6. If there is irrigation water shortage in the area, how do you measure the amount of irrigation water and what irrigation water saving technologies are used (mulching, skip irrigation)?
7. How do check and how often irrigation water is tested for quality, if any?
8. Do you practice irrigation scheduling (rate and time of water application)?
9. If irrigation is a common practice, do you use supplemental irrigation during rain shortage and, if not why don't you use (rain water is enough, no water source, other reasons)?
10. If irrigation is a common practice, do you use fertilizers for irrigated crops and, if so, which fertilizers and at what rate and method of application?
11. If irrigation is a common practice, what method of drainage of excess water do you use?
12. How do you resolve irrigation water conflict and what are the challenges in using irrigation?

Water Harvesting and Moisture Conservation:

1. Is water harvesting a common practice in your area and, if so, what is the purpose of water harvesting?
2. If water harvesting is a common practice, what method and types of water harvesting practices do you apply?
3. If water harvesting is a common practice, where do you place the appropriate site for water harvesting (within the farm land or outside)?
4. If insitu/exitu moisture conservation is a common practice in your area, what is the method and purpose of moisture conservation (for double cropping, ground water recharge, etc.)?
5. What are the challenges associated with water harvesting and moisture conservation in your area?

Part II

General Information About Specific District/Kebele/Village

Description	Area (Ha)		
	District	kebele	village
Land use land cover (LULC)			
Cultivated land			
Irrigated land			
Grazing land			
Forest			
Degraded land			
Settlement			
Others			
Climate			
Rainfall			
Temperature max			
Temperature min			
Humidity			
Agro-ecology			
Dominating soil type			
Average land holding size			
Use of organic fertilizer & bio-fertilizers			
Compost			
Vermicompost			
Farm yard manure			
Bio-slurry			
Bio-fertilizer			
Others			

Type and number of water harvesting? Number of functional water harvesting?