Effects of traditional and project water ponds and herder perceptions on the vegetation changes in Borana rangelands of southern Oromia, Ethiopia

By

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Declaration

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Dedication

This thesis is dedicated to my beloved father Obbo Dula Buyo, who passed away in 2005, my mother Rahel Disassa, and my husband Gutu Olana.

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Abstract

This study was conducted in Borana rangelands of Ethiopia to compare project and traditional water ponds in terms of vegetation diversity, to analyze the effects of distance from water ponds on plant life form species richness and land cover, and to assess pastoralists' perceptions of changes in vegetation species richness along radial distances from ponds. Vegetation sampling, household survey and key informant interviews were used for data collection. A total of 320 plots were sampled from four project and four traditional water ponds. 50 households were surveyed, and five key informants were interviewed. Regression between distance and vegetation variables was used to identify the trends of different vegetation variables along the radial grazing distances from the ponds. Descriptive statistics was used to examine the perceptions of pastoralists about the dynamics of vegetation in their area and factors associated with water points in changing vegetation species diversity. Narrative analysis was used to describe personal experiences of key informants about the effects of water ponds on vegetation diversity changes. There were significant differences between traditional and project water ponds in herbaceous richness, wood density and bush cover, while no significant differences were observed between project and traditional water points in terms of herbaceous density, woody species richness, basal cover and herbaceous cover. Herbaceous species richness and bush cover showed contrasting trends with proximity to the water pond types. Herbaceous and tree density showed a linear increase for both pond types. Basal and grass cover showed a slight increase with proximity to project water points, while it showed a slight decrease with proximity to traditional water points. There is a considerable change in vegetation diversity in the area as perceived by the pastoralists. Woody plant species were perceived to be increasing while herbaceous plant species were perceived to be decreasing. This corresponds with the empirical evidence obtained through scientific methods, suggesting the need for collaborative approach in range management and biodiversity conservation. Ban on fire, animal dispersal of seeds, overstocking, overgrazing, development of water ponds, reduction of grazing land, trampling, settlement and the disintegration of traditional management practices were the perceived contributing factors for changes in vegetation diversity. The relative contribution of project water ponds in degrading the rangelands was perceived to be far greater than that of traditional ones. Differences in management of project and traditional water points have implications for the *conservation of vegetation diversity and future water developments in the Borana rangelands of southern Ethiopia.*

Key words: Borana, herders, rangeland, project and traditional water ponds, vegetation variables, grazing gradients, trampling, overgrazing, perception

1. Introduction

The development of water points in arid savannas increases localized overgrazing that shifts plant species composition (Florian, et al., 1997). The direct and indirect impacts of water results from radical changes in land use systems from the traditional seasonal uses to year-round grazing. For this reason, provisions of water in arid and semi-arid communal rangelands in Africa in particular have contributed to rangeland degradation (Owen-Smith, 1996; Florian, et al., 1997). Water points encouraged heavy concentrations of livestock that caused heavy trampling along radial distances from water points (Nangula and Oba, 2004). Greater impacts around water points create piospheres of "desertified" areas, changing plant species composition and probably contributing to loss of plant biodiversity (Florian, et al., 1997; Thrash et al., 1993). Studies have shown that permanent water points for large herbivores have impacts on the herbaceous species richness (Florian, et al. 1997; Thrash et al., 1993). Herbivore concentrations caused herbaceous species richness along the radial distances from water points through trampling, and dung and urine deposition (Tharsh et al., 1991). The changes in biodiversity along grazing gradients may be in terms of shifts from perennial grass species and promotion of annual grasses (Thrash et al., 1993). "A perennial, palatable, obligate seed reproducer may become locally extinct under conditions of heavy grazing, whereas annual, unpalatable species with prolific seed production may increase under variable rainfall and grazing" (O'Connor, 1994).

Grazing also influences competitive ability of preferentially grazed plant species compared to less grazed ones (Walker, 1987). Overgrazing is believed to cause a decline in the basal cover of herbaceous vegetation (O'Connor, 1994). This has been found to cause an increase in forbs, grazing tolerant species, and promote bush encroachment on previously grass-dominated vegetation communities (Skarpe, 1986; Walker, 1987). The effects of livestock grazing and trampling around the water points and their effects on changes in plant life forms and shifts in plant species composition from grass-dominated to bush-dominated states (Parker and Witkowski, 1999; Thrash, 2000; Landsberg, et al., 2003) might accelerate the processes that lead to desertification (Nangula and Oba, 2004). This is probably due to the differential nature of grazing pressure as the livestock move away from the water points. The decreasing herbivore impacts away from perennial water points could be the consequence of increased trampling and selective grazing pressure that increases towards water points (Parker and Witkowski, 1999). The number of species that decrease along the water point might significantly overweigh those species showing increasing trends towards the water points. At high grazing pressure, there would be an overall decline in species richness with increasing proximity to water points (Landsberg, et al., 2003).

The changes in vegetation in relation to water points might vary between project water points and the water points traditionally developed by the local communities. By virtue of being familiar with their environment and managing their water sources for centuries, the local communities are aware of the ecological changes that are associated with water development and could provide valuable information that would complement the knowledge necessary for land use planning and rangeland monitoring (Oba and Kaitira, 2006). The need to integrate scientific knowledge and traditional ecological knowledge is becoming more evident than ever. It is from this viewpoint that this study intends to incorporate herders' perceptions of changes in vegetation species diversity.

In the Borana rangelands of southern Ethiopia, where rainfall is scarce and unpredictable both temporally and spatially (SOS Sahel, 2002), access to grazing resources are limited by water availablity, particularly during the dry season, after the rainfall-produced surface pools had dried up (Desta and Coppock, 2000). Despite the general scarcity of water in the area, the community have over several centuries developed elaborate systems of water management. Although it is not the main concern of the thesis, it is important for the readers to appreciate these indigenous systems of water and range management. It is from these perspectives that the recently project-introduced ponds are compared with the traditional ponds on their direct and indirect impacts on vegetation. The different systems of management might provide important explanations for the variations on the pacts of the different types of ponds on vegetation.

1.1. Borana traditional water management

In Borana, Helland (1980) classified water sources into three major parts: wells, occasional water and temporary water. Traditional wells are the most important sources of water. The wells are called *ela* and are of two types: one sunk deep through the limestone rocks (called *ela tulla*)[1] and the other shallow (called *ela adadi*). *Tulla* well complex represents an ancient source of water used by the pastoralists. The wells usually last for a longer period of time, but require a large input of labor to lift water to the surface (Coppock, 1994). Surface rainwater is another source of

[1] "Tulla" means high yielding, usually in reference to water.

water in Borana. It is easily accessible, but lasts only for weeks to months during the early dry season (Helland, 1980; Coppock, 1994).

Temporary water sources include traditional water ponds, which could be either hand-dug or man-improved natural basins, and is called *hara* (Watson, 2003; Helland 1980*)*. *Hara*-ponds are of different sizes, small and big. They are used for collecting rainwater that may last for few weeks or months after the end of the rainy season. Although pond management is not as strict as that of traditional wells, traditional water ponds have rules and regulations similar to those of wells. The regulations are in terms of different sets of rights (Helland, 1980). The hand-dug ponds, similar to the deep wells, belong to specific clans and the relationship between individual person of the clan and the well or the traditional pond is known as *konfi*—the person or whose ancestor first struck the ground for developing the water pond. The *konfi* is inherited, but the manager of water, is often the person whom the users appoint and he is called *abbaa herregaa*—father of the water rota. The *abbaa herregaa*, with help from the water management committee, allocates the rota for watering their livestock, while water for human consumption is not regulated (Helland, 2002; Oba, 1998) and ownership of water points does not preclude use by others. The rest of the community gains access through labour contribution for digging and maintenance.

The pastoralists tend to use common management strategies, including the combination of sedentary livestock management and mobility. The later involves moving livestock to areas with high rainfall where pasture is available. Mobility is towards the well rangelands during the dry season and in the opposite direction during the wet season (Oba and Kotile, 2001; Coppock, 1994). This has direct implications for pasture and water use. The traditional mode of pastoral land use does not cause excessive overuse (Oba, 1998).

Unlike pasture, water is not freely accessible in Borana. Yet the consumption of pasture is limited by capacity of water. Animals used to drink from wells in three-day cycle during the dry season (Helland, 1982). The scarcity of water forces the herders to follow rotational grazing strategy. In the rainy season, herders moved to areas where surface water or traditional ponds allowed use of grazing. Movement of herders from wet season pasture to dry season pasture takes place after the exhaustion of temporary water, but before that of grazing resources (Oba, 1998). Dry season range management involves locating settlements 10-15 km from the wells. By virtue of its role in regulating stocking rates (Helland, 1980) and reducing overgrazing (Oba, 1998), traditional water management reduced the problems of rangeland degradation around water points. This has changed with development of surface water ponds by the government.

1.2. The differences between traditional and project water ponds

There are differences between Borana traditional water management and project water management. In this section, we focus only on traditional water ponds and its management differences from project water ponds.

Access to water, including project and traditional water ponds, is allocated by *abbaa herregaa*. Based on ownership status and the overall water institution, the selection and influence of *Abbaa herregaa* differs between types of water sources. For traditional ponds, he can be selected from the clan that dug the ground or the clan may select someone from the community. Regarding project ponds, the community selects *Abbaa herregaa*. Depending on the capacity of water, *Abbaa herregaa* decides whether all types of livestock, or calves and the weak, or lactating animals should drink. Thus, from the early to the late dry season, the composition of herds drinking at the ponds would shift as the amount of the water in the ponds diminish, while only critically ill animals and young animals would be allowed. The last water is only used for human consumption.

Unlike the clan ponds, community-appointed person, after whom the pond might be called, manages the development project ponds, but the difference is that the waters of the latter are considered as public resource, while that of the former are semi-private. In the public, project ponds, labour is contributed for maintenance but use of the water is not on equally strict basis. To keep the cleanness of traditional ponds, all the pond users participate in removing mud from the area and keep around the pond clean. The removing of mud every year contributes to the actual digging and expansion of the traditional ponds, while the project ponds were dug using heavy earth moving machinery. Water users have rights to know how the water is managed. People who fail to adhere to the laid down *aadaa seera hara-eela* (the customary laws governing the use of the waters of ponds and wells) will be punished by the water council and will be forced to remove seven watering stick lengths of mud or repair the fencing. Serious cases of violation will amount to refusal of water (Oba, 1998). As for the project ponds, access is more open for all, and the restrict rules of the traditional ponds might not apply.

There are two reasons for this, including the rules of water use. The traditional water ponds have less capacity of water (each serves 200 to 2000 livestock) than project ponds and would therefore not attract livestock from the neighbouring regions unlike the project ponds. Because of their ephemeral nature they are used for domestic use, for weak animals as well as calves and lactating animals. Those with bigger capacity also serve larger herds. Prior to use, the Borana would hold a meeting to decide on when to start and when to stop using the pond water for livestock. They also would decide on who is eligible and which type of livestock, whether calves or lactating or non-lactating animals, are supposed to drink. The ownership as mentioned earlier is semi-private but the management decisions are by the public.

For project ponds, the rules for management are less strict. The water point belongs to the whole community or the PA. The water serves all types of livestock and used for domestic purpose. Often the project ponds have larger capacity of water (each supports 2000 to 15,000 animals) than the traditional ponds. It means that project ponds can serve six times more livestock as compared to traditional ponds. Mainly due to the easy access by all people in the neighbourhood, the impact on vegetation is expected to be greater than those of the traditional ponds. For this reason, the community usually associates the development project ponds with environmental degradation. This research will analyze the impacts of the ponds on vegetation change in relation to community perceptions.

In this thesis, the main aim is to understand how recent changes in development of water ponds by development projects contributed to land deterioration. In addition to the breakdown of the management of the project-introduced water sources, the official banning of fire had contributed to increased bush encroachment that also exacerbated problems associated with land degradation (Oba, 1998). Furthermore, water development attracts settlements, which reduce mobility and increase reliance on artificial water sources for the greater parts of the year (Sandford, 1983). Preoccupied by the objectives of improving human welfare through increased access to water for households, water development interventions overlooked the impacts on vegetation biodiversity.

This thesis hypothesized that rangelands with developed water points, where the traditional systems of regulations of land use are weaker, will be degraded more. This will be reflected by losses in vegetation cover and decline in plant biodiversity compared to the traditional water ponds. This study had three specific objectives. These are (1) to compare artificial and traditional water ponds in terms of herbaceous plant species richness and woody plant composition, (2) to analyze the effects of distance from water ponds on plant life form species richness and cover, and (3) to assess changes in vegetation biodiversity and the contributing factors as perceived by the pastoralists.

2. Methods

2.1. The Study Area

The study was conducted in Borana region of southern Oromia, Ethiopia. The region has arid and semi-arid climate. The landscape is gently undulating across an elevation of 1000 to 1600m (Coppock, 1994). Rainfall is bimodal with the long rains (*ganna*) expected between March and May, and the short rains (*hagayya*) between October and November. The short rains of *hagayya* are followed by long dry season (*bona hagayya*) (Oba and Kitole, 2001; Coppock, 1994). Rainfall ranges from 200 to 500 mm per year (Abesha and Waktola, 2000). Droughts or periods of unusually low rainfall are expected (Blench & Marriage, 1999). The main source of water supply for livestock and human consumption are the traditional wells and surface rainwater harvested from ponds. To cope with variability of range production, the Borana combined mobility and sedentary livestock management (Helland, 1980).

2.2. Sampling and Data Collection

2.2.1. Vegetation sampling

Sampling of vegetation was conducted in three locations. For the study, eight water ponds comprising four project-developed and four traditional ponds were selected. In *Yaaballo*, one of the largest project ponds (*Haroo Bakkee*) was selected. In *Dubulluq*, two project ponds (*Haroo Bokossaa* and *Haroo Waaqoo*) and two traditional ponds (*Haroo Jaaroo* and *Haroo Diid-borbor*) were selected, whereas in *Dida Hara*, one project pond (*Haroo Hayya-gurraachaa*) and two traditional ponds (*Haroo Taaroo* and *Haroo Alii-gollichaa*) were selected. Dida Hara and Dubulluq sites comprised both project and traditional water ponds. From each site, all water ponds were selected purposively on the basis of ease of accessibility.

For each water pond, transects were laid in two compass directions, covering a radial distance of 1 km from the water points. For each transect, herbaceous and woody plant life forms were sampled at 50 m intervals. Nested plots were used to sample herbaceous plant life forms using 1 x 1 m plots, whereas trees and shrubs were sampled using 5 x 5 m plots. Herbaceous species data collection sheet and woody sample data collection sheets were used to record raw vegetation data (see Annexes 1 and 2). For the woody plant species, the samples were categorized into seedlings (<0.2 m height), saplings (1.0-1.5 m height) and mature (> 2.0 m height). From each plot, individual species were counted and species richness was recorded, and, grass cover, basal cover and bush cover were estimated. A total of 320 plots were sampled. The data was collected after the long rainy season when the grasses are at the full growth stage in order to identify different types of species by their flowers and seeds.

2.2.2. Household surveys

Household surveys were conducted in two Pastoral Associations (PAs), called Dubulluq and Dida Hara, in Yaaballo district. These sites were selected purposively in order to match with the sites where vegetation sampling was conducted. From the two PAs, about 25 settlement areas or villages were selected based on accessibility. From the settlement areas, 50 households were randomly selected for interview.

The respondents were asked if they have perceived any increasing, decreasing, and disappearing plant species in the area, and their perceptions of the connections between the management of various water sources and changes in biodiversity (see Annex 3). The Borana predicted environmental changes using the *gada* system as their timescale for making predictions. Each *gada* is divided into eight years, after completion of which the power is passed on to another *gada* (Legesse, 1973). For the purpose of crosschecking and verifying the information, five key informants, with extensive knowledge and experience with water and range management, were interviewed from the selected villages and the same questions were posed to them.

2.3. Data analysis

A linear model (SAS, 2001) was used to analyze the effects of pond types (traditional vs. project pond) and radial distances along grazing gradient from water points on the dependent variables, including herbaceous species richness, herbaceous density, basal cover of perennial grasses, woody species richness, wood density, bush cover and herbaceous cover. Differences were considered at $P < 0.05$.

Regression analysis was used to analyse the trends of different variables (herbaceous species richness, herbaceous density, basal cover of perennial grasses, woody species richness, wood density, bush cover and herbaceous cover) along the radial grazing distances of traditional and project water points. Descriptive statistics, such as frequency and percentage, were also used to examine the perception of pastoralists about the dynamics of vegetation in their area and factors associated with water points in changing vegetation diversity. The narratives of key informants were used to describe personal experiences and reflection on the effects of water ponds on changes in vegetation diversity of the rangeland.

3. Results

3.1 Differences between project and traditional water points in vegetation composition, wood life forms, and effects of radial distance from pond type

3.1.1. Effects of pond type on vegetation variables

There were significant differences between traditional and project water ponds in terms of herbaceous species richness, wood density and bush cover (t-tests, all $P < 0.05$, Table 1). Greater mean values were observed for herbaceous species richness along radial distances for the traditional ponds, while greater mean values were recorded for wood density and bush cover for project ponds. However, no significant differences were observed in herbaceous density, basal cover, woody richness and herbaceous cover between the two pond types (t-tests, all $P > 0.05$, Table 1).

Table 1: Mean comparison of vegetation variables between traditional and project ponds in Borana, southern Ethiopia, 2005

Parameter	Pond type: Traditional	Pond type: Project	t-test	P
Herb richness m^{-2}	6.4±0.2	5.5±0.1	12.91	***
Herb density m^{-2}	96.1±5.2	85.4±4.0	2.68	NS
Basal cover m^{-2}	25.4±1.4	23.4±1.1	1.32	NS
Woody richness 25 m^{-2}	3.0±0.2	3.2±0.1	1.43	NS
Wood density 25 m^{-2}	5.2±0.4	6.8±0.3	8.48	**
Bush cover (%)	12.5±1.7	22.5±1.3	22.54	***
Herbaceous cover (%)	37.6±1.4	35.2±1.1	1.81	NS

*** $P < 0.001$, ** $P < 0.01$, NS $P > 0.05$

Contrary to traditional water points, greater mean values were recorded for mature, as well as saplings and seedling woody plants for project water points. Statistically, however, only mature woody plants showed significant differences between the traditional and project ponds ($t = 9.42$, $p < 0.05$, Table 2).

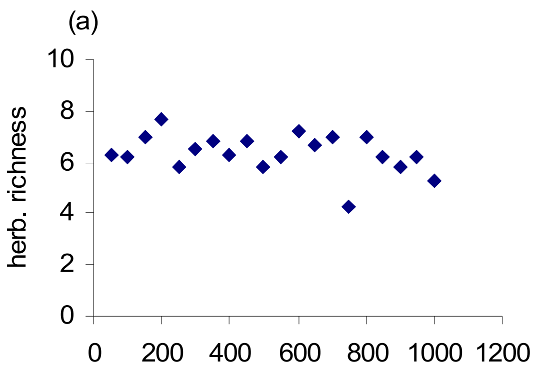
Table 2: Mean comparison of woody plant density (25 m^{-2}) by height size classes between traditional and project ponds in Borana, southern Ethiopia, 2005

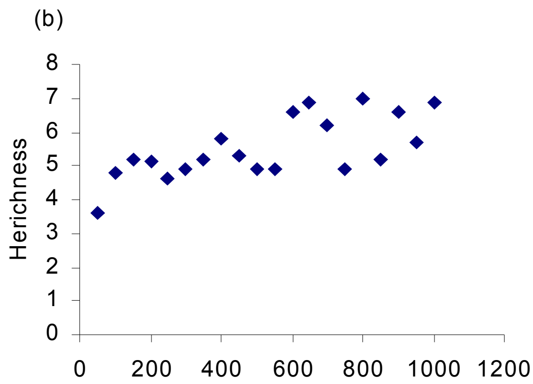
Parameter	Pond type: Project	Pond type: Traditional	t-test	P
Mature	1.6±0.1	0.9±0.2	9.42	**
Sapling	2.5±0.2	2.2±0.2	0.67	NS
Seedling	2.7±0.2	2.5±0.2	0.75	NS

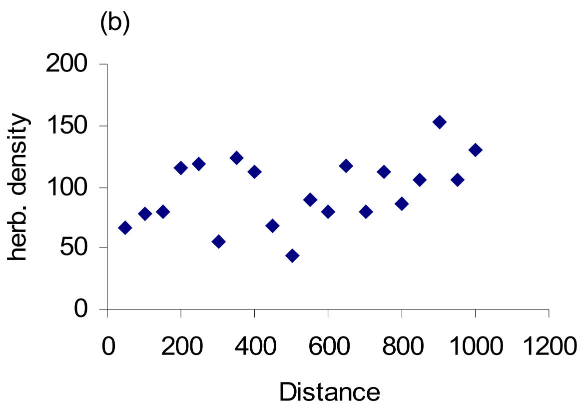
** $P < 0.01$, NS $P > 0.05$

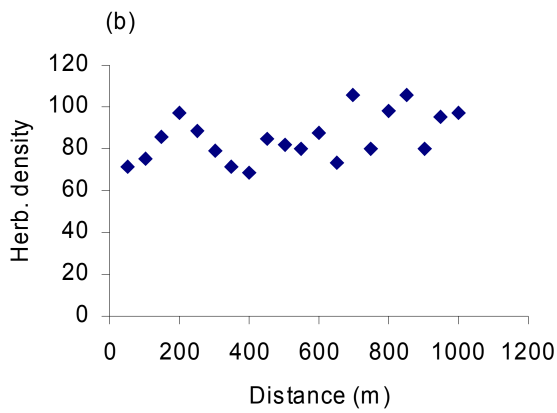
3.1.2. Effects of radial distance from water points on vegetation variables

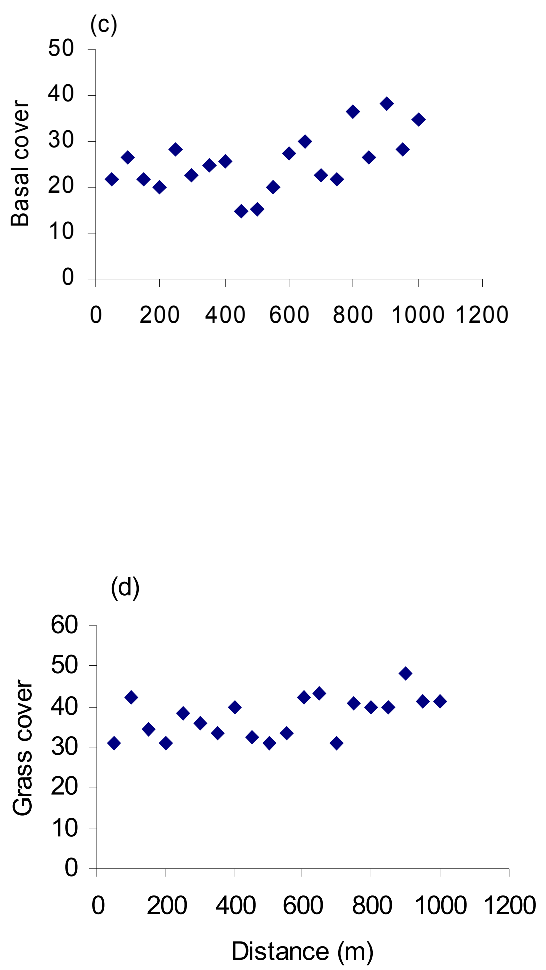
Herbaceous and tree species richness slightly increased along the radial grazing distance of traditional water points as one moves towards the water points (Figure 1a and Figure 3a). With proximity to project water points, herbaceous and tree species richness were reduced (Figure 2a and Figure 4a). The trend portrayed by herbaceous density along the radial grazing distances from traditional and project water points were comparable. In both cases, the trends showed a slight increase along the radial grazing distance of the water points (Figure 1b and Figure 2b).











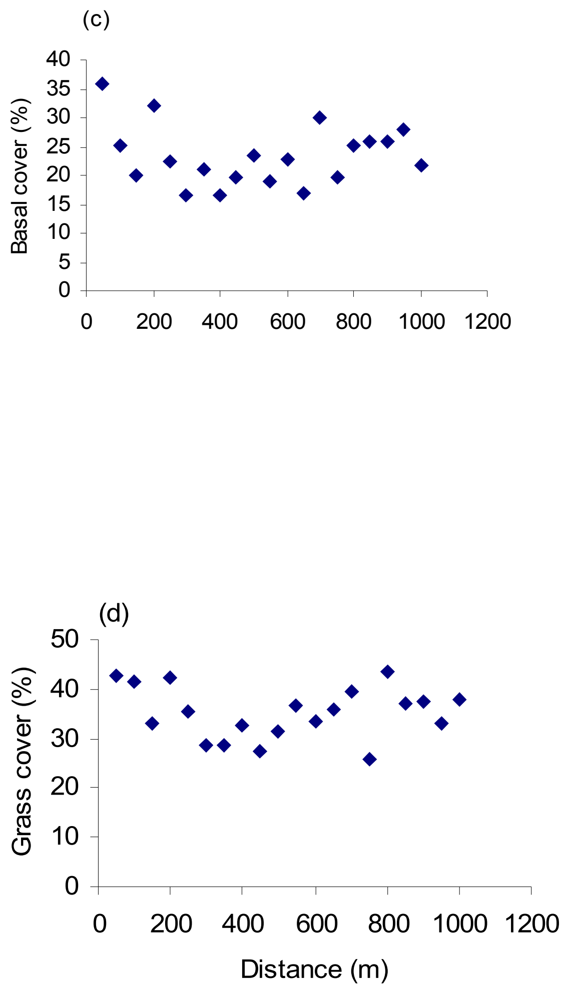


Figure 1: The trend of herbaceous richness, herb density, basal cover and grass cover along radial grazing distance of traditional water points

Figure 2: The trend of herbaceous richness, herb density, basal cover and grass cover along radial grazing distance of project water points

Basal and grass cover (Figure 2, c and d) showed a slight increase with proximity to project water points, whereas with proximity to traditional water points, basal and grass cover showed a slight decline (Figure 1, c and d), but away from the water points, the variables showed an increasing trend beyond 500 m distance.

Bush cover showed a contrasting trend between radial grazing distance of traditional and project water points. For traditional water points (Figure 3c), it showed very low cover at distance near to the water points and a slight increase beyond 300 m. For the project water points (Figure 4c), a high cover was observed near the water points and a slight decline was exhibited after 500 m distance. Tree density showed a slight increase as one moves away from the traditional water points, showing slight increases at 200 m, beyond which it showed a linear trend up to the distance of 800 m and thereafter the changes depicted a sharp decline (Figure 3b). For the project water points, tree density portrayed an increasing trend all along the radial grazing distance (Figure 4b).

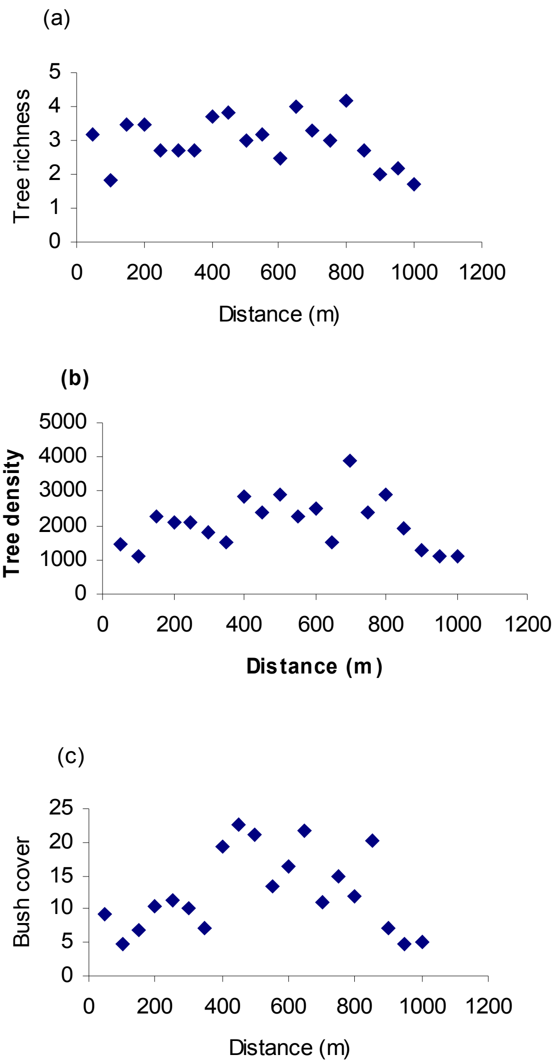


Figure 3: Tree richness, tree density and bush cover for traditional water points

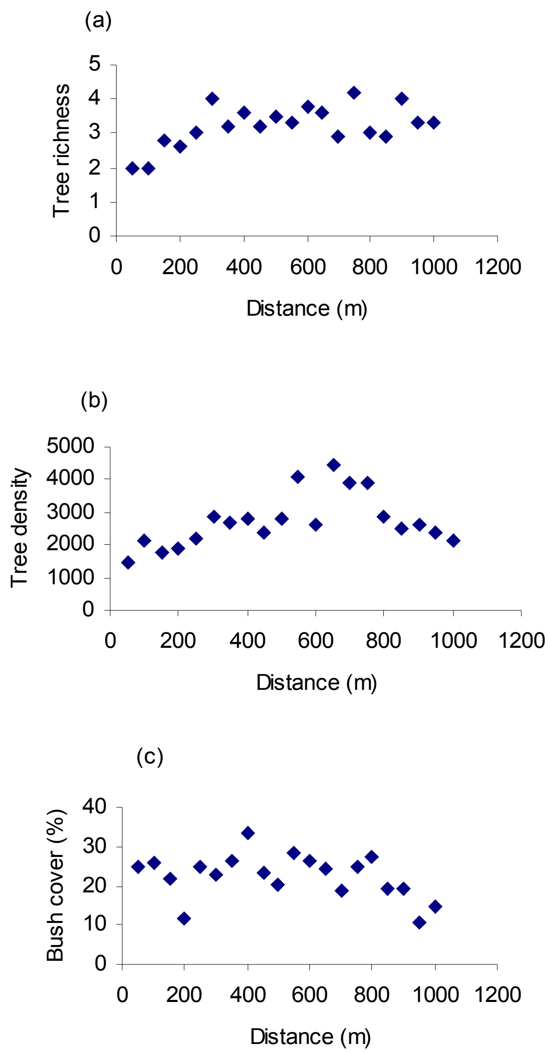


Figure 4: Tree richness, tree density and bush cover for project water points

Means for herbaceous and wood species richness increased with increasing distance from project water points. Whereas the herbaceous species richness (t-test, $P < 0.05$) was significantly varied, no significant differences were observed in wood species richness (t-test, $P > 0.05$, Table 3). On the contrary, with increasing radial distance from traditional water points, the means for herbaceous and woody species richness decreased, despite the changes not being significant (t-test, all $P > 0.05$). Similarly, bush cover showed contrasting figures with increasing radial distances between the project water points and the traditional ones. The means increased with increasing distance from traditional water points, while it decreased with increasing distance from project water points (t-test, $P > 0.05$).

Table 3: Mean comparison of traditional and project water ponds by effects of radial grazing distance on vegetation variables in Borana, southern Ethiopia, 2005

	Traditional pond			Project pond		
	< 500 m	> 500 m		< 500 m	> 500 m	
Parameter			t-test			t-test
Herbaceous richness m²	6.53 ± 0.24	6.18 ± 0.24	0.99 NS	4.94 ± 0.20	6.09 ± 0.20	15.82 **
Herbaceous density m²	86.24 ± 8.18	105.90 ± 8.18	2.89 NS	80.38 ± 5.24	90.32 ± 5.24	1.80 NS
Basal cover m²	22.18 ± 1.60	28.70 ± 1.60	8.57 **	23.26 ± 1.68	23. 54 ± 1.68	0.01 NS
Wood richness 25 m²	3.05 ± 0.22	2.87 ± 0.22	0.34 NS	2.99 ± 0.19	3.43 ± 0.19	2.76 NS
Wood density 25 m²	5.15 ± 0.46	5.21 ± 0.46	0.01 NS	5.75 ± 0.54	7.85 ± 0.53	7.68 *
Bush cover (%)	12.23 ± 1.79	12.70 ± 1.79	1.03 NS	23.53 ± 2.05	21.45 ± 2.05	0.51 NS
Herbaceous cover (%)	35.00 ± 1.57	40.25 ± 1.57	5.58 *	34.38 ± 1.73	36.03 ± 1.73	0.45 NS

* $P < 0.05$, NS $P > 0.05$

Although herbaceous and wood density as well as basal and herbaceous cover showed changes in greater mean values along the radial distances beyond 500 m for both water points, only herbaceous and basal cover showed significant responses (t-test, *all* $P < 0.05$) to the effects of radial distances from traditional water points, but failed to differ significantly in response to radial distances from project water points. Furthermore, wood density did not vary significantly by radial grazing distance from traditional water points, but it differed significantly (t-test, $P < 0.05$) by the effects of radial distance from the project water points. Herbaceous density (t-test, $P > 0.05$) failed to show significant responses to the effects of radial distances from project or traditional water points.

3.2. Effects of distances from project and traditional water points on woody plants

The seedlings of woody plants showed significant increase with increasing radial distance from project water points (t-test, $P < 0.05$), but were not significantly influenced by the effects of radial distances from traditional water points, although greater mean value was recorded within the 500 m distance along the 1 km transect (Table 4). Saplings displayed greater mean values with increasing distances from traditional water points, but failed to disclose changes along the radial grazing distances from the project water points. Although it was not statistically significant, mean values for mature woody plants appeared to be high with increasing distance (>500 m) as compared to the distances closer to the water points (<500 m).

Table 4: Mean differences of woody plant structure by effects of radial distance from project and traditional water points in Borana, southern Ethiopia, 2005

Variables	Traditional pond		t-test	Project pond		t-test
	<500 m	>500 m		<500 m	>500 m	
Mature	0.67 ± 0.23	1.17 ± 0.23	2.41NS	1.47 ± 0.21	1.79 ± 0.22	1.10NS
Sapling	1.98 ± 0.27	2.48 ± 0.28	1.63NS	2.45 ± 0.24	2.45 ± 0.24	0.00NS
Seedling	2.53 ± 0.30	2.37 ± 0.30	0.16NS	1.85 ± 0.27	3.56 ± 0.27	19.74***

* $P < 0.05$, NS $P > 0.05$

3.3. Vegetation species richness

Total plant species richness recorded within traditional (56) and project (58) water points were comparable. The frequency of herbaceous species was 44.6% of the total species sampled, while that of woody species comprised 55.4% for the traditional water points. For project water ponds, herbaceous species richness accounted for 43%, whereas woody species accounted for 57% of the total species. *Sporobolus pyramidals* was the dominant herbaceous species for both pond types. Among herbaceous plant species, herbaceous legumes and other herbs had a comparable frequency for both project and traditional water points. *Entropogon somalensis* had greater frequencies along traditional water points, while *Cynodon dactylon* was with larger frequency within project water points. Among woody plant species, *Acacia mellifera* and *Commiphora africana* (both invasive species) were dominant along traditional and project water ponds, respectively. Although *Commiphora africana* is the dominant species for project ponds, it was also listed among species with greater frequency for traditional water points in addition to *Grewia tembensis* and *Grewia evolute. Acacia drepanolobium* and *Ormocarpum trichocarum* were among the most frequent woody species within project water point areas (Table 5).

Table 5: Percentage of individual herb and woody species composition at traditional and project water ponds

Species	Local name	Life form	% Species Composition	
			Traditional pond	**Project pond**
Annual grass		H	3.00	0.67
Arstida Kenyensis	*Biilaa*	H	1.42	0.32
Chrysopogon auheri	*Alaloo*	H	5.23	7.30
Bothriochloa radicans	*Saagettuu*	H	0.94	0.32
Cenchrus Ciliaris	*Mata gudessa*	H	2.10	2.15
Cynodon dactylon	*Sardoo*	H	4.03	18.20
Entropogon somalensis		H	17.42	4.45
Chloris roxburghiana	*Hidoo lucole*	H	1.41	0.68
Cyperus rubicundus	*Sattuu*	H	0.40	1.09
Dactyloctenium aegyptium	*Ardaa*	H	0.50	0.46
Digitaria naghellensis	*Ilmoo gorii*	H	0.32	0.06
Digitaria milanjiana	*Hidoo*	H	0.53	0.46
Eleusine jaegeri		H	-	*0.46*
Lintonia nutans	*Hidoo(lucole)*	H	*0.02*	*0.20*
Eragrosts cilianensis	*Ardaa*	H	*8.10*	*6.34*
Herbaceous legumes		H	*7.00*	*7.65*
Harpachne schimperi	*Biila seericha*	H	*0.02*	*0.04*
Hetropogon contortus	*Seericha*	H	*4.23*	*2.11*
Leptothrium senegalens	*Biilaa diidaa*	H	*2.54*	*3.82*
Panicum coloratum		H	*1.51*	*0.76*
Panicum turgidum		H	*1.20*	*0.82*
Panicum maximum	*Loloqa*	H	*0.08*	-
Penstium mezianum	*Ogoondhicho*	H	*0.03*	*0.20*
Penstium straminum		H	*0.70*	*0.13*
Sporobolus pyramidals		H	*26.74*	*31.10*
other herbs		H	*11.44*	*10.23*
Acacia brevispica	*Hammareess a*	W	*6.70*	*5.31*
Acacia bussei	*Hallo*	W	*3.34*	*3.61*
Acacia etabaica	*Alqabessa*	W	*3.63*	*4.60*
Acacia nilotica	*Burquqqee*	W	*0.40*	*1.50*
Acacia tortilis	*Dhadacha*	W	*1.82*	*4.00*
Acacia mellifera	*Saphansa -*	W	*18.00*	*4.00*
Acacia seyal	*Waccu*	W	-	*0.21*
Balanties aegyptiaca	*Baddana lu'o*	W	*0.50*	*0.53*
Boscia mossambicensis	*Qalqalcha*	W	*2.10*	*1.83*
Dichrostachys cinerea	*Jirimee*	W	*1.40*	*2.02*
Grewia tembensis	*Dheekkaa*	W	*10.60*	*6.06*
Lannea rivae	*Handaraka*	W	*2.60*	*7.00*
Acacia drepanolobium	*Fuleensa*	W	*0.20*	*9.00*
Commiphora africana	*Hammessa*	W	*12.50*	*23.50*
Commiphora kua	*Callaanqa*	W	*0.70*	*1.00*
Commiphora schimeri	*H. Qayyoo*	W	*1.00*	*0.64*
Commiphora habessinica	*Hoomachoo*	W	*6.00*	*5.00*
Cordia gharaf	*Madheera*	W	*1.00*	*0.31*
Grewia evolute	*Harooressa*	W	*8.52*	*1.52*
Grewia villosa	*Ogomdii*	W	*4.80*	*2.44*
Ormocarpum trichocarum	*Buutiyee*	W	*0.60*	*7.60*
Commelina africana	*Qayyoo*	W	*0.10*	*1.06*
Rhus ruspolii	*Daboobessa*	W	*1.00*	*1.06*
Kleinia squarrosa	*Xixiixxuu*	W	*0.20*	*0.31*
Euphorbia tirucalli	*Aannoo surre*	W	*0.60*	*0.20*
Hibiscus sparseaculeatus	*Dunuunnuu*	W	*2.00*	*0.74*
Boswellia neglecta	*Dakkara*	W	*1.60*	*2.23*
Delbergia microphylla	*Wolchaamala*	W	*2.36*	*2.02*
Cactus tree		W	*1.47*	*0.32*
Aloe species	*Hargeessa*	W	-	*0.20*
Euclea divinorum	*Mi'eessaa*	W	*0.50*	*2.44*
	Gololee	W	*2.45*	*1.00*

Fursa	W	*1.82*	*0.32*

3.4. Pastoralists' perceptions of changes in vegetation diversity and contributing factors

3.4.1. Changes in vegetation diversity

The Borana herders perceived that woody plant species were increasing while herbaceous plant species were decreasing in their area (Table 6). According to more than 40% of the respondents the changes occurred since *gada* Gobbaa Bulee (1968-1976), while about 27% of the respondents indicated that the increase of bush encroachment had occurred since the *gada* Jiloo Aagaa (1976-1984), and the rest 22% said it was since *gada* Boruu Madhaa (1992-2000) and *gada* Boruu Guyyoo (1984-1992). The increasing species accounted for 61% (14) of the total species, while the decreasing ones accounted for 39% (9). From the respondents, 91% indicated that the most escalating woody plant species was *Commiphora africana*, while 40% of them mentioned *Acacia bussei* as an expanding woody species. Similarly, a sizeable number of interviewees confirmed *Acacia mellifera* and *Acacia drepanolobium* as increasing woody plant species. Among the grass species, *Pennistum mezianum* was indicated as an increasing species. From herbaceous plants, more than half of the respondents mentioned *Cenchrus ciliaris* as the rapidly decreasing species, followed by *Chrysopogon auheri*, *Lintonia nutans, Digitaria naghellensis* and other herbaceous species.

Table 6: Changes in vegetation as perceived by pastoralists of Borana, southern Ethiopia, 2005

Plant life forms	Increasing species in the area	Declining species in the area	Percent (%) of respondents
Commiphora africana	√		91.0
Acacia drepanolobium	√		31.9
Acacia nilotica	√		30.0
Acacia reficiens	√		26.0
Acacia millifera	√		33.7
Acacia tortiles	√		23.2
Acacia bussei	√		40.0
Pennistum mezianum,	√		7.1
Acacia brevispica	√		15. 4
Acacia etabaica	√		15.4
Acacia seyal	√		13.2
Rhus ruspoli	√		15.4
Dalbergia microphylla	√		8.3
Acacia Senegal	√		23.1
Cenchrus ciliars		√	52.3
Digitaria naghellensis		√	12.0
Lintonia nutans		√	41.2
Grewia villosa		√	5.0
Chrysopogon auheri,		√	45.1
Bothriochla insculpsa		√	7.1
Panicum maximum		√	2.0
Eragrostis cilianensis		√	2.0
Hyparrhenia anamesa		√	2.0

According to the pastoralists, there were different factors that contributed to the increase and decrease of plant species (Figure 5). The government's policy of banning the use of fire, seed dispersal from woody plants, and disintegration of traditional management practices were among the most influencing factors for increasing plant species. Overstocking, reduction of grazing land and development of ponds and trampling were the top factors reducing plant species as perceived by Borana pastoralists.

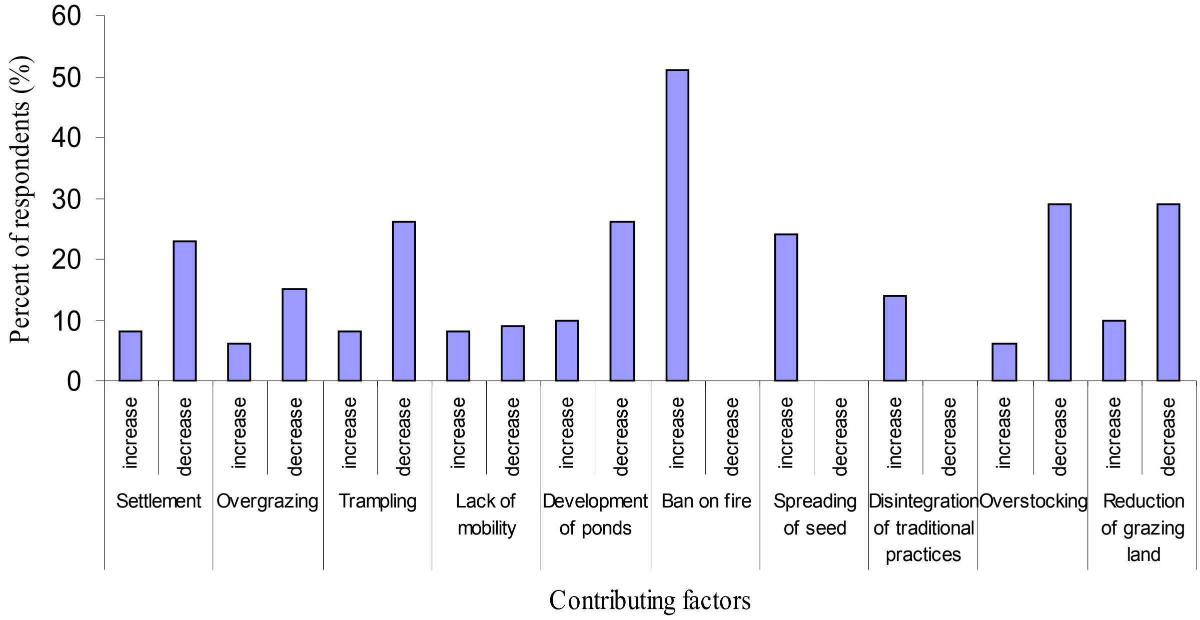


Figure 5: Respondents' perceptions of different factors contributing to vegetation change in Borana, southern Ethiopa, 2005

Considering water ponds as contributing factors for vegetation dynamics, respondents were asked the species that have been increasing and decreasing in the area, and their responses were summarized (Table 7). While woody plant species were increasing, herbaceous plant species were decreasing due to ponds. *Commiphora Africana, Tussee*[2] and *Acacia drepanolobium* were species perceived to be highly increasing among the woody plant species. *Cenchrus ciliars, Chrysopogon auheri* and grasses in general were perceived to be highly decreasing among the herbaceous plant species.

[2] We could not find a scientific name for *Tussee*. It is the local name used to refer to shrubs, but some researchers use it to refer to encroaching bushes.

Table 7: Increasing and decreasing species due to ponds as perceived by pastoralists, southern Ethiopia, 2005

Species	Increasing species due to ponds	Decreasing species due to ponds	Percent (%) of respondents
Commiphora africana	√		49.1
Acacia drepanolobium	√		26.3
Acacia nilotica	√		18.2
Acacia bussei	√		18.2
Acacia brevispica	√		7.3
Acacia etabaica	√		5.5
Tussee	√		30.1
Cenchrus ciliars		√	66.0
Digitaria naghellensis		√	9.1
Chrysopogon auheri		√	63.8
Digitaria milanjiana		√	49.0
Hetropogon contortos		√	10.6
Arstida kenyensis		√	4.3
Dactyloctenium aegyptium		√	7.0
Grasses in general		√	68.1

While Table 7 depicts the effects of ponds in general, the relative contribution of project and traditional ponds, as perceived by respondents, is shown below (Figure 6). Project ponds, according to the herders, contributed twenty times as much as traditional ponds to the increasing of woody plant species and the decreasing of herbaceous plant species.

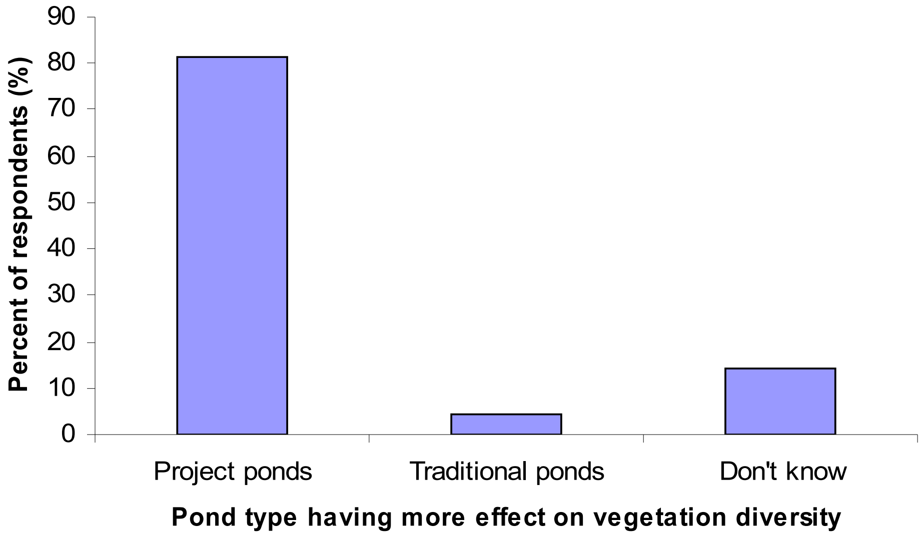


Figure 6: Comparative effects of project and traditional ponds on vegetation diversity as perceived by herders in Borana, southern Ethiopia, 2005

3.4.2. How ponds contribute to vegetation change

The pastoralists perceived that water ponds have a considerable contribution to promote increasing or decreasing plant species. This is due to factors that are associated with water ponds that contribute to vegetation dynamics (Table 8). Trampling, size of ponds, overstocking and lack of mobility are the most important causes of increase, whereas trampling, size of ponds and overgrazing are the most important causes of decline in plant species, in that order of importance. Most of the factors mentioned were interlinked in contributing to the increment of woody plant species and the reduction of herbaceous plant species.

Table 8: Respondents' perceptions of how ponds contribute to the dynamics in vegetation diversity, southern Ethiopia, 2005

Cause	Increment	Decrement
	Percent (%) of respondents	Percent (%) of respondents
Settlement	10.6	21.3
Spreading of seed	4.3	2.0
Overgrazing	17.0	53.2
Size of ponds	25.5	53.2
Trampling	32.0	59.6
Lack of mobility	21.3	23.1
Number of ponds	12.8	21.6
Disintegration of traditional practices	0.0	19.0
Overstocking	21.3	57.5
Reduction of grazing land	12.8	17.0

3.4.3. Herder narratives on pond impacts on the environment

According to a key informant, "if there were water in every village there would not have been this much problem, but now because of scarcity of water, all livestock are concentrated around one place, where there is water, and this became hazardous for the rangeland." Other herders were of the view that water in the neighbourhood of settlements could contribute to environmental degradation. Another herder adds "although we have water scarcity, because of the trampling effect caused by livestock as they always come in search of water from different directions, when we (people in one Pastoral Association) were asked to have a project water pond in our area, we refused."

4. Discussion

4.1. Differences between project and traditional water points, in terms of vegetation composition, wood life forms and effects of radial distance from pond type.

4.1.1. Effects of pond type on vegetation variables

The significant difference observed in herbaceous species richness, wood density and bush cover between traditional and project water points probably reflected the effects of management between the two pond types. Traditional water points were smaller watering not more than 2000 livestock per, while the project ponds could serve up to 15,000 livestock per day. Besides, the rules and regulations of use being stricter for traditional ponds than for project ones, the project water ponds tends to be open for all, whereas the traditional water ponds are under the control of clans. The management difference therefore seemed to have implications for conservation and loss of biodiversity. Around the different types of ponds, the extents of degradation were probably related to the numbers of livestock watered daily and the presence or absence of regulations of stocking density (Todd, 2006).

Although there was no difference observed between the two pond types in herbaceous density, woody richness, basal cover and herbaceous cover, greater mean values were recorded for traditional water points with the exception of woody richness. This implies that traditional water ponds were in better range condition than project water ponds.

Although only mature woody plants differed significantly between pond types, the recorded greater mean values for mature, sapling and seedling woody plants along the radial grazing distance of project water points implies that project water points had more contribution to bush encroachment than traditional ones. Increases in woody vegetation have been commonly reported as a response to heavy grazing pressure (Coppock, 1994).

4.1.2. Effects of distance from project and traditional water points on vegetation variables

There were contrasting trends between herbaceous species richness and bush cover along the radial grazing distances from project water points. The decrements of herbaceous species richness in the vicinity of project water points perhaps resulted from heavy concentrations of livestock causing overgrazing and trampling that affects more of palatable and sensitive species, while allowing the growth of less sensitive and non-palatable plant species. This is similar to what has been reported for wildlife (Thrash, 2000).

My results confirm what has been reported by Todd (2006) that "areas close to watering points tend to be over utilized and associated with a reduction in plant species richness." My research also confirmed the evidence reported earlier that impacts on plant species was less far away from the water points where the pressure of grazing was less (Nangula and Oba, 2004; Oba, et al., 2001). The effect of grazing pressure on species richness would be more pronounced in areas with a short grazing history (Oba, et al., 2001). This has an important implication given the lifetime difference between project and traditional water points, the former being a much more recent phenomenon. The selectiveness of livestock (Squires, 1981) for more palatable species will not let plant species withstand high grazing pressure near more permanent water points than the temporary water sources (for boreholes see Moleele, 1994). Changes in herbaceous species richness could also be the effect of bush encroachment (Coppock, 1994).

The increase in bush cover with proximity to project water points suggests that the growing effect of grazing pressure next to the water points could promote expansion of woody plant species at the expenses of herbaceous plant species. This study supports the finding of Archer (1990), who stated that "increases in woody plant abundance are normally accompanied by decreases in herbaceous production and undesirable shifts in composition." The selective grazing of livestock probably increases the abundance of shrub species at the expense of more palatable and less grazing tolerant species (Milchunas, et al., 1988). Moleele and Perkins (1998) also showed that areas next to the boreholes are extremely susceptible to invasion by encroaching woody plant species.

Unlike project water points, herbaceous species richness slightly increased while bush cover decreased as we move towards traditional water points. The increasing trend in herbaceous species richness is probably related to the fact that traditional ponds served only a limited number of animals and for short period of time. This avoids the concentration of a large number of livestock in one pasture area for long period of time, in effect saving palatable and grazing intolerant plant species from further destruction. It is also because of reduced grazing pressure from livestock and human disturbance that gives herbaceous plant species equal chance of growing around the water point, allowing all to coexist. While management of the traditional water points has a positive contribution for herbaceous species richness, it discouraged the expansion of bush cover by maintaining the competitive ability of herbaceous vegetation over the bush plants.

The increase of bush cover with increasing radial distance from traditional water point could not be explained in terms of grazing pressure alone. It was probably more attributed to other factors like topography, soil types and the fact that the bushes are not burned for long period of time due to policy ban on fire. For example, *Haroo Jaaroo,* which is located in *Dubuluq* attracted our attention for the potential contribution of topography as it exhibited a steep slope and more degraded environment as compared to other traditional ponds. Changes in bush cover may be due to external and internal factors that shifted patterns of land use (Oba, et al., 2000). Abundance of herbaceous species showed similar trends along the radial grazing distances for both traditional and project water points. But this should not be mistaken to imply that the herbaceous condition is comparable for both pond types.

The increasing trends observed for basal and grass cover with proximity to project water points were likely to be related to contrasting responses by different species, i.e., when trampling and overgrazing negatively affect palatable and sensitive species, grazing tolerant and non palatable species flourished at the expense of palatable and sensitive ones. The consequence is increases in total species pool, suggesting that species richness is not a good indicator of land degradation (see also Oba et al., 2003). Therefore, the figure gives false impression that the vegetation condition in terms of grass and basal cover around the water point was good. Todd (2006) suggested that the impact of grazing pressure is more pronounced on plant species richness than plant cover. The location of some project water points and the season in which data was collected might also had contribution to the trends of basal and grass cover around water points. The time during which the data were collected was after the long rainy season and that might have contributed to good vegetation condition. In terms of locality, some ponds, especially *Haroo Bakkee,* which is located in *Yaaballo* and

Haroo Bokossaa, located in *Dubulluq,* were situated in a slightly valley area with the tendency to accumulate runoff water and top soils that have been washed from upper lands. It seems that the project ponds were intentionally located in such areas. This potentially facilitates soil erosion, which apparently contributes to rangeland degradation.

4.1.3. Effects of distance from project and traditional water points on mature, sapling and seedling plants

Herbivore trampling around watering points negatively affects the survival of seedlings of woody plants (Brits, et al, 2002). The results of this study also indicate that the trampling effects around project water points probably restricted the chance of woody seedlings to establish. In effect, the reduced number of seedlings could also have an impact in reducing the number of saplings and mature woody plants around the water points. The increased number of seedlings and mature woody plants at distances greater than 500 m would be the result of less trampling. Whereas the absence of difference in sapling woody plants between distances less and greater than 500 m can be due to livestock browsing, at distances greater than 500 m, where the impacts were less, tree saplings were more established.

The larger number of seedlings observed around traditional water points could be due to less trampling that increased the survival of the seeds of mature woody plants. However, the mean values for mature woody plants were larger along project water points than traditional ones. The larger number of sapling and mature woody plants observed at distances beyond 500 m for traditional water points could not be explained by management alone, but also could be due to environmental factors such as topography and soil types as well as the overall effects of the ban of fire and expansion of bush encroachment.

4.2. Vegetation species richness

Along the radial distances from the project and traditional water points, there were comparable types of vegetation composition. This was probably because water ponds developed in geographical proximity (the same geographical area) have the possibility to be comparable in vegetation composition although the frequency of occurrence varied. The larger frequency of *Sporobolus pyramidals* along both project and traditional water points, suggests that the species was tolerant to grazing pressure. The comparable frequency of herbaceous legumes and other herbs within project and traditional water points indicate that management had no influence on it. The forbs were promoted by heavy trampling in the piospheres around water points of both pond types.

The dominance of *Commiphora africana* and the greater frequency of *Acacia drepanolobium* as well as *Ormocarpum trichocarum* along project water point suggest that the areas around project water points were under the invasion of encroaching woody plants. Oba (1998) indicates that *Acacia drepanolobium* and *Commiphora african* are among species accounted for bush encroachment and their population structure illustrates cycles of invasion. *Acacia millifera*, a dominant woody species, and *Commiphora Africana*, with higher frequency along traditional water points, are encroaching woody plant species. By comparison, although *Grewia tembensis* and *Grewia evolute* had higher frequencies along the water points, they were valuable woody plant species for livestock and human use Coppock, 1994). The availability of valuable woody plants with higher frequency along traditional water points indicates that the area comprising traditional water ponds are more favourable for livestock.

4.3. Pastoralists' perceptions of changes in vegetation diversity and contributing factors

4.3.1. Changes in vegetation diversity

The time reported by respondents about the occurrence of vegetation diversity changes in Borana corresponds with the beginning of development intervention in the area in the 1980s. The end of *gada* Gobbaa Bulee (1968-1976), which marked the decline of herbaceous plant species according to more than 40% of the respondents, is associated with the start of the Third Livestock Development Project, from 1976-1986 (Coppock, 1994). Water development was one of the components of the project. The suggestion was that there was a probable link between project water points and deterioration of range condition as perceived by the pastoralists. Other development components of the project, including veterinary service, forage development, road development and ranching might have increased livestock population, encouraged settlement and reduced mobility, increasing the number of livestock around water points. This could have contributed to range degradation in the view of the Borana herders.

According to the respondents, *Commiphora Africana*, *Acacia bussei*, *Acacia mellifera* and *Acacia drepanolobium* were among the top species that showed increasing trends in the area. This was confirmed by the vegetation sampling around the different pond types. The exception was *Acacia bussei,* for which we had lower frequency. The species predominates high uplands where the ponds were not represented. Perhaps, the herders were referring to the larger grazing lands where the species is considered to have encroached (Gemedo Dalle, 2005). The decreasing herbaceous plant species mentioned by respondents also occurred in low frequencies. This indicates that the perception of respondents and the empirical field data all confirmed and decreasing herbaceous layer and the increasing woody cover in the pond-water rangelands. There was a clear link between the decline of the herbaceous vegetation, increase in bush cover and rangeland degradation even from the perspectives of the Borana herders.

4.3.2. Factors contributing to changes in vegetation diversity

There were different factors that contributed to increasing or decreasing plant species in the pond water rangelands in Borana. According to the herders interviewed, fire banning had contributed to the expansion of wood plant species. According to the herders, seed scattering by livestock facilitated bush expansion (cf. Tamene Yigezu, 1990). The Boran who were cattle keepers blamed the increasing use of the area by camels that as browsers were said to have contributed to seed dispersal of the invasive species. The herders were of the view that when the herbaceous vegetation was reduced, they offered less competition with the woody species and, therefore, the seeds of woody plant species were easily established (see also Oba, 1998). Thus, fire banning shifted the balance between tree and grass layers, increasing the competitive advantage of trees over grasses (Coppock, 1994). The interviewees repeatedly mentioned that places that earlier had no wood vegetation before the development of the ponds were invaded by woody plant species.

4.3.3. Increasing and decreasing species due to development of water ponds

The Borana explained the contribution of water ponds in increasing woody and decreasing herbaceous plant species more in relation to project water ponds. They have highlighted that project ponds are more influencing than traditional water ponds in terms of vegetation dynamics. They explained how development of ponds contributed to the increment of woody and decrement of herbaceous plant species in the area in association with different factors, most of which are interlinked. They perceived that the settlement policy, which was initiated by the Derg[3], was the cause for water development. The developed water sources have larger capacity than the water sources they traditionally have had–traditional ponds. Because of its larger capacity, the project ponds support large number of livestock. Due to this, the areas around water points are highly trampled and overgrazed. In places where there is large quantity of ponds, grasses are overgrazed while tree cover is expanding. In areas where the number and the size of ponds were increasing, pastureland was decreasing and overstocking was becoming a serious problem.

Moreover, the restriction of movement that comes in relation to settlement policy forced herders to give up traditional mobility between wet and dry season pasture. In the past, during the wet season, livestock used to drink from hand-dug or traditional ponds. Since the water is small in volume, it did not sustain livestock throughout the season, so they moved to other pasture area leaving the place fallow for one year, and during the dry season they returned to the wells. However, with the development of project ponds, which are open-access resources, traditional practices disintegrated. This enhanced a year-round land use that resulted in overgrazing of the grass cover. The heavy use has left a serious impact on range and the environmental conditions.

Because of the concentrations of livestock in smaller areas, the palatable grass species, such as *Cenchrus ciliars*, *Chryspogon auheri* and grasses in general, have been over-utilized, as the pastoralists have pointed out. Apart from describing the prevailing situation as extremely undesirable, herders emphasized their worries about the future.

The narratives of the respondents emphasized the concerns and different interpretations of the community about the environmental problems associated with the project water ponds. At first glance, the two seem to be contradicting. While some herders suggested that having more water sources in different villages could reduce the decline of herbaceous plant species, the others were of the view that the development of water in their area increased the decline of herbaceous plant species in that area.

[3] Derg refers to the former Ethiopian regime that was on power from 1974-1991.

According to the latter group, although the scarcity of water was a problem in their area, their refusal of water-pond development emphasized the links between degradation of range with water ponds. Similarly, the idea suggested by the first group indicated that, as far as there was lack of sufficient water in every village, there would be a concentration of livestock around available water ponds. The poor distribution of livestock would ultimately result in loss of herbaceous plant species. Both respondents are thus concerned about trampling and overgrazing caused by livestock, as they are concentrated around water points, consequently leading to rangeland degradation.

As the pastoralists have perceived, *Commiphora Africana*, *Tussee* and *Acacia drepanolobium* were increasing woody plant species, whereas, *Cenchrus ciliars, Chrysopogon auheri* and *grasses in general* were among decreasing herbaceous plants species due to development of ponds. This indicates that the decreasing species perceived to result from the development of water ponds were more adversely affected by the trampling effect and overgrazing, which was more pronounced around the water points. The encroaching woody plant species and their dominance had an effect of increasing unpalatable species over the palatable ones.

5. Conclusion

The rangelands of Borana, southern Ethiopia, are undergoing serious challenges, one of which could be associated with the recent water development interventions. Our findings support the hypothesis that rangeland degradation is more evident with project water points than the traditional ones. There were significant difference between project and traditional water ponds in relation to herbaceous species richness; wood density and bush cover, suggesting management difference has a contribution in changing vegetation diversity. Even though there were no significant differences observed between the two pond types in herbaceous density, woody richness, basal cover and herbaceous cover, greater mean values were recorded for traditional water points with the exception of woody richness. The implication was that traditional water ponds were in better range condition than project water ponds.

There were contrasting trends between project and traditional water points with respect to herbaceous species richness and bush cover. Herbaceous species richness showed increasing trend with proximity to traditional water points, while it showed decreasing trend with proximity to project water points. Contrary to this, bush cover increased towards project water points, while it decreased towards traditional water points. The reduction of herbaceous plant species and the increment of bush cover in the vicinity of project water points indicate that the trampling and overgrazing marked around the water point are much more serious in terms of biodiversity loss. The opposite trend observed for traditional water ponds has important implications for conservation of the rangelands. This suggests that traditional water management has a positive contribution for herbaceous species richness, which has implications for management of biodiversity. While the traditional water management discourages the growth of non-palatable and the expansion of woody plant species, project water ponds negatively affect more of palatable and sensitive species, allowing the growth of non-palatable and promote expansion of woody plant species.

The increasing trend of basal cover and grass cover with proximity to project water points was related to the contrasting responses by different species that increased total species pool, and may be due to the location of some water sources and the timing of data collection.

Although only mature woody plants have marked significant difference between the two pond types, sapling and seedling woody plants showed greater mean values for project water points than traditional ones, suggesting that wood encroachment is more pronounced around project water points than traditional ones. Seedling woody plants showed significant increase with increasing radial grazing distance from project water points, but there was no significant difference for traditional water points although greater mean values were observed within the distance less than 500 m than the distance away from the water points (>500 m). This implies that trampling is more pronounced around project water points than traditional water points, in effect reducing the establishment of seedling woody plants around the former.

There are comparable types of species composition along project and traditional ponds. *Sporobolus pyramidals* was the dominant herbaceous species for both pond types. Encroaching woody plants with larger frequency were more marked along project water points than traditional ones, whereas traditional water points encompass also valuable woody plant species with larger frequency.

The prevailing perceptions of Borana pastoralists confirm that there is a considerable change in vegetation diversity in the area, most markedly during the last few decades. As perceived by the pastoralists, woody plant species were increasing while herbaceous plant species were decreasing. This corresponds with the empirical evidence obtained through scientific methods, suggesting the need for collaborative approach in range management and biodiversity conservation.

The perceived factors that contributed to the vegetation dynamics of the area include ban on fire, spreading of seeds, overstocking, overgrazing, development of water ponds, reduction of grazing land, trampling, settlement and the disintegration of traditional management practices. These factors are not mutually exclusive; most of them are interlinked. For instance, the development of water ponds is associated with settlement, trampling, overstocking and overgrazing, ultimately contributing to the increment of woody plant species and the reduction of herbaceous plant species. The relative contribution of project water ponds in degrading the rangelands was perceived to be far higher than that of traditional ones.

In general, differences in management of project and traditional water points have implications for vegetation diversity and range condition. As opposed to project water ponds, we observed better herbaceous condition and less expansion of woody plant species for traditional project ponds. The elaborate water management of the society must, therefore, have enormous contribution in sustaining the rangelands. The observance of water-source capacity in deciding extent of use is a vital management strategy as it limits livestock and human population that may be supported by the surrounding rangelands. The established tradition of coping with water shortage and enumerating rules and regulations for access to water also avoid free ride. These contribute to maintaining better range condition. That is why, in Borana, water is considered not just as a resource but also a tool for range management (Oba, 1998).

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Annexes

Annex 1: Herbaceous species data collection sheet

Study centre ______________ Altitude __________ GPS ___________ Soil type _________

Landscape ______________ Season ______________ Date ______________

Transect distance __________ Transect no. __________ Plot size __________

Vegetation ______________ Bare ground ________ Fresh weight ______ Dry weight______

Grazing pressure ____________ Grass cover _________

Species list	Present	Abundant	Common	Occasional	Rare	No. of spp.	Type	Forage value	Ls spp.

Type: 1 = Decreasers, 2 = Increasers, 3 = Invaders

1 = Highly palatable, 2 = Palatable, 3 = Less palatable, 4 = Non-palatable

Annex 2: Woody sample data collection sheet

Study centre ______________ Altitude __________ GPS ___________ Soil type _________

Treatement type __________ Plot number __________ Plot size __________

Bush cover ______________ Bare ground ________ Grass cover

Species list	No. of mature plants	No. of saplings	No. of seedlings	Height (HT)	Stem diameter (SD)	Crown diameter (CD1+CD2)	Type	Use for humans	Fora Ls s

Type: 1 = Invasive, 2 = Non-invasive

<0.2 m = Seedlings, 1.0 – 1.5 m = Sapling, >2 m = Mature

Vegetation type: 1 = Bush, 2 = Shrub, 3 = Wooded grassland, 4 = Open grassland

Annex 3: Survey Questionnaire for Household Interview

Remark: *This questionnaire is meant to collect data for purely academic purpose. The data will not be used for any other purpose and will be treated confidentially. Thus, respondents are encouraged to feel free in providing the required data.*

Instructions for Enumerator

1. Upon arrival, greet the herder and others in the household.
2. Introduce yourself (name, profession, etc.) and clearly explain the purpose of the visit/survey before you begin the interview.
3. Ask one question at a time, patiently and politely, and make sure that the respondent understands the question.
4. For open questions, write the respondent's response clearly.
5. For closed questions, circle the number(s) of the answer(s).

Date of interview	______________________________
Enumerator's (interviewer's) name	______________________________

1. Name ____________________________________

2. Sex 1. =Male 2. =Female

3. Marital status 1 = Single 2 = Married 3 = Widow(er) 4 = Divorced

4. Age __________

5. Name of the Pastoral Association [PA] _________________________

6. Name of the village (Olla) ___________________________

7. What is the source of water for domestic use and livestock?
   a) Traditional Pond
   b) Traditional Well
   c) Project Pond
   d) Flood Water
   e) Other(s) specify _______________________

   i) If it is traditional pond, how is the ownership of the pond?
   a) Owned by clan
   b) Communally owned
   c) Owned by state
   d) Other(s) specify _______________________

ii) If it is traditional well, how is the ownership of the well?

a) Owned by clan
b) Communally owned
c) Owned by state
d) Other(s) specify ________________________

iii) What is the primary purpose of traditional well?

a) Home consumption
b) For calves
c) For weak animals
d) For livestock
e) Other(s) specify

iv) If it is artificial pond , how is the ownership?

a) Owned by clan
b) Communally owned
c) Owned by state
d) Other(s) specify ________________________

v) What is primary purpose of project pond?

a) Home consumption
b) For calves
c) For weak animals
d) For livestock
e) Other(s) specify____________________________

8) If the traditional wells and ponds are owned communally

a) What is/are the criterion/ criteria/ requirement/s to make use of the water?

____
____
____

b) Is it easily available?

a) Yes b) no

c) Does it have any special arrangement?

a) Yes b) no

If yes, what kinds of arrangements does it have? ______________________________
____

d) How many livestock can drink from it per day? _____________________________

e) How long does water last? ____

9) If the project ponds are owned communally

a) What is/are the criterion/ criteria/ requirement(s) to make use of the water?
____
____

b) Is it easily accessible?
a) Yes b) no

c) Does it have any special arrangement?
a) Yes b) no

If yes, what kinds of arrangements does it have? ________________________
____

d) How many livestock can drink from it per day? ________________________

10) Does the accessibility of water differ between different ownerships?
a) Yes b) no

If yes, explain the difference ______________________________________
____

11) Is the accessibility of water differs from one water source to another?
a) Yes b) no

If yes, how they differ? Why? _____________________________________
____

12) Does the accessibility of water differ from one water source to another?
a) Yes b) no

13) If you are the owner of the water:
a) How can you manage it?
b) Can you easily make use of it? a) Yes b) No
c) Is it accessible for the whole year? a) Yes b) No
d) If you say no (c), for how long can you use it?
e) How many livestock can drink from it?
f) If there are water constraints, how can you manage?

14) How is vegetation cover in your area according vegetation species richness? Is it
a) Increasing
b) Decreasing
c) No change
d) Other idea ____

i) If it is increasing, since when? ___________________________________

ii) If it is decreasing, since when? __________________________________

iii) If you say it is increasing to question number 14, do you specifically know which type (s) of species is/are increasing?   a) Yes   b) No

iv) If you say yes, what are they?

____

____

v) If you say it is decreasing to question number 14, do you specifically know which type (s) of species is/are increasing?   a) Yes   b) No

vi) If you say yes, what are they? _____________________________________

15) How is vegetation cover according to plant species richness? Is it

a) Increasing
b) Decreasing
c) No change
d) Other observation____

i) If increasing, why? ____

____

ii) If decreasing, why? ____

____

16) Do you think the development of ponds have contribution in increasing the number of woody and herbaceous plant species?

a) Woody plant species   a) Yes   b) No

b) Herbaceous plant species   a) Yes   b) No

i) If the answer is no to question number 16a and 16b, skip question number 17, 18 and 19 and go to question no. 20.

17) If you say yes to question number 16a which woody plant species are increasing due to development of ponds? ____

____

18) If you say yes to question number 16b which herbaceous plant species are increasing due to development of ponds? ____

____

19) How can ponds contribute t increment of woody and herbaceous plant species?

a) Woody plant species

____

b) Herbaceous plant species

____

20) Do you think ponds have contribution in decreasing woody and herbaceous plant species?

a) Woody plant species a) Yes b) No

b) Herbaceous plant species a) Yes b) No

21) If you say yes, to question number 20a which woody plant species are decreasing due to development of ponds? ____

____

22) If you say yes, to question number 20b which herbaceous plant species are decreasing due to development of ponds?

____

____

23) How can ponds contribute to decrement of woody and herbaceous plant species?

a) Woody plant species

b) Herbaceous plant species

24) Which one of the ponds is more influencing on?

a) Woody plant species i) Project ii) Traditional

b) Herbaceous plant species i) Project ii) Traditional

25) Do you think why? ____

____

26) How far is the distance between your house and the available pond? ________________

27) How many ponds are available in your village? __________________________________

28) Age of pond (Gada timeline) ____