Where does the water flow? Roads runoff, soil erosion, groundwater, livelihoods and poverty alleviation in Tigray, Ethiopia

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Summary

In rural development theory and practice, roads are built to improve people’s mobility and enhance access to markets, administrative centres, schools and health posts, and are credited with important socio-economic changes. A less studied aspect is the impact of roads on hydrological resources, as roads interact with existing surface and groundwater systems, reorganising the distribution of water related hazards and resources among the population, with significant consequences on their livelihoods. In Ethiopia, the government has embarked in a massive road construction programme over the last decade, mainly to serve the needs of an essentially rural population and agrarian economy. In parallel, the government has also invested significantly into soil and water conservation measures and irrigation to serve the needs of a population whose livelihoods depend heavily on rain fed agriculture. Based on fieldwork conducted in 2014 in the semi-arid region of Tigray, Ethiopia, this report explores the physical and socio-economic impacts of road related surface and groundwater flows – and how people cope with and adapt to them. We argue that two distinctive objectives of improving road connectivity and improving water availability for irrigation – are linked and could be served by the same infrastructure, which we call multifunctional roads.
1. Introduction

Where does road runoff flow? A considerable amount of literature deals with the consequences of roads on development and their effects in terms of poverty alleviation. In rural areas roads are built to improve people’s mobility and connectivity to markets, administrative centres, schools and health posts, and are credited with important socio-economic improvements. However, one aspect that has received little attention is the effect of roads on water flows, and how these positively or negatively affect people.

In Tigray, a semi-arid region situated in the North of Ethiopia, the effects of runoff on the landscape are considerable. Whereas flows of water and silt triggered by torrential rains devastate the land and people’s assets in summer, during the nine month long dry season water becomes the scarce and precious resource on which all life depends. Where surface and groundwater flows and how water can be stored and reused - and by whom - become crucial questions. And evidence shows that roads, when they are built or upgraded, modify considerably the hydrology of the place, and therefore the allocation of water hazards and resources.

Based on fieldwork conducted in 2014 in Tigray, this article attempts to understand how the impacts of hydrological changes triggered by road construction affect positively and negatively the life of socially differentiated individuals and households, and how people adapt to and cope with these effects. Taking the route corridor Sinkata – Hawzien-Abreha Weastbeha-Wukro as a case-study, we explore the geographical, socio-economic and political determinants of processes induced by road and water interactions, and how the negative impacts of roads could be minimised and the positive ones maximised to serve the needs of the local population. We further investigate their effects – real and potential – on equity and poverty alleviation, and advocate for road planning processes that are inclusive and take local knowledge and multifunctionality into account.

Section two examines the key literature on roads and development, and roads, water and livelihoods, before presenting the objectives of the study. Section three introduces the methodology, the study sites and the theoretical framework that informs this work. Section four frames the context of the study in terms of vulnerability, assets and livelihoods. Section five analyses the socio-physical effects of roads in their complexity: the physical consequences of road, as well as the consequences of roads on the hydrology of the place; the consequences these have in terms of livelihoods and well-being; coping mechanisms and adaptation strategies; and finally the distribution of roads consequences among the population. Section six analyses political processes of road construction for different types of roads, and the degree to which people are included or excluded from planning and construction processes. The final sections brings together the main findings of the study and makes recommendations in order to integrate the multifunctionality concept into road construction and improve the effects of roads in terms equity and poverty alleviation.

1 Also called Freiweign
2. Problem and objectives

Roads and development

Contrarily to an idea widely spread among many development theorists and practitioners, the link between roads and development is far from straightforward. To put it simply, the effects of roads are complex, difficult to measure, and if people *often* benefit from road construction, its effects are unequally distributed among the population.

Roads often form an important component of social and economic development theories and poverty alleviation strategies. Modernisation theory argues that the development of transport is conducive to economic growth (Bryceson et al. 2008: 359), an argument backed by econometric demonstrations. For instance, based on statistical correlations between economic growth and a host of other factors, and a sample of 43 countries in Asia, Africa, Fan and Rao find that “agricultural spending, irrigation, education, and roads contributed strongly to growth” (Fan and Rao 2003: 29). Overall, the main economic justification for road construction is market integration: “by reducing trade costs and promoting economic specialization across space, transportation infrastructure is said to be a determining factor of growth” (Burgess et al. 2010: 2). By opposition “the lack of infrastructure is often mentioned as one of the main reasons of African underdevelopment” and a deterrent to trade expansion (Buys et al. 2006): “overland transport is so difficult and costly that Africa’s diverse regions remain largely isolated from one another” (Buys et al. 2006: 2). This, in turn, acts as disincentive to industrialization (Shiferawa et al. 2012: 3), putting manufacturing firms (which are intensive users of infrastructure services) at a comparative disadvantage. Therefore, economies with poor infrastructure record a low share of manufacturing production in GDP.

“One of the most glaring differences between the developed and developing countries is in the densities of their respective road networks. Indeed the density or quality of a country’s road system is often used as a measure of its state of development” (xii)


Likewise, in rural development roads are “logically assumed to alleviate [...] poverty associated with spatial isolation” (Bryceson et al. 2008: 460). The argument is based on the idea that roads provide farmers with access to markets for agricultural inputs, labour, and outputs, and therefore stimulate agricultural production. Based on the observation that poverty is generally concentrated in areas where the market has a weak presence, it is argued that “roads allow the market to infiltrate peripheral areas”, and “permit the inhabitants of those areas to access the jobs, services, and higher standards of living in the core” (Rigg 2002: 619). Similarly, Porter argues that roads increase access to social services and markets for the rural poor - schools, healthcare,
labour markets, and credit facilities - services that have a direct impact on socioeconomic well-being and human development (Porter 2002).

However, both in theory and in practice, the links between roads and development remain contested. Already in the 1950s and 1960s, Hirshmann argued that investing in transport infrastructure was “costly and unpredictable” (Edmonds 1998: 26), and that economic growth would lead to the development of transport, not the other way round; Wilson argued that “transport [was] no more an initiator of growth than any other form of investment” (in Edmonds 1998: 26). As some authors argue, there is still a critical lack of evidence regarding roads’ consequences in terms of development (van de Walle 2002). Studies that posit a direct and uncontested link often use inadequate methodologies or lead to unconvincing results (deGrassi 2005), while benefits “are often seen as so obvious [...] that they are listed rather than discussed” (Wilson 2004: 525). As a result, “short-term and long-term distributive impacts of transport projects, particularly on low-income groups, are not well understood” (deGrassi 2005: 53).

One may cite at least three reasons why the link between and roads and development came to be discredited. First, because the effects of roads tend to be complex and context specific, and sometimes even negative. Hook and Howe criticize reports and statements that “posit a rather direct connection between road investments, poverty alleviation, and economic growth”, for “these statements do not sufficiently specify conditions under which road investments will lead to positive growth or poverty alleviation outcomes” (Hook and Howe 2005: 4). They add: “there is a significant risk that misguided transport investments will actually harm the development process and adversely impact the lives of the poor” (Ibid.: 11). For instance, DeGrassi shows that increased connectivity can also have detrimental effects through increased competition for workers or through increased imports (deGrassi 2005). Roads can harm groups of people and villages, and they can lead to a decline in livelihoods, just as they can contribute to them: the effect of roads are context specific (Rigg 2002). Roads are sometimes reproached for destroying existing livelihoods, generating environmental destruction, creating disputes over resources, and increasing social differentiation, thereby generating social conflicts (Perz et al. 2007; TRL 1997)(Humbert-Droz and Dawa 2004; Smethurst 2000), increasing the speed of disease transmission and dependency on oil prices (and other imports).

Second, roads do not necessarily serve the needs of local populations, let alone the rural poor, because their needs have been misconceived. In general, the “transport needs of rural population can be characterized as the movement of small loads over relatively short distances” and the predominant means of transport is often on foot (Barwell et al. 1985: 130). As a consequence of road construction, non-motorized and intermediate means of transport are sometimes forgotten and displaced from the market (Fairhead 1992; Fouracre 2001). In Africa, evidence suggests that roads tend to be overengineered relatively to the density of traffic (Gwilliam et al. 2008), as traffic remains very low, especially on rural roads. The focus on expensive motorable roads has also created problems for governments because of their maintenance costs (Barwell et al. 1985: 135; Hine and Rutter 2000). Also, planners have too often focused on increasing mobility through road provision, when the bigger question is that of
“accessibility” to social services (Dawson and Barwell 1993: 41); instead of improving access, such interventions have led to off-road markets and social services being neglected, affecting local dwellers and more particularly those with reduced mobility. In fact, several authors argue that interventions other than road construction are more likely to alleviate poverty (Hook and Howe 2005)

Finally, roads are not necessarily conducive to development, because “roads are not enough” (Dawson and Barwell 1993). While evidence suggests that benefits often do not accrue to those living outside a 3- to 4-kilometre-corridor along the road (Håkangård 1992; Porter 2003), benefits tend to be captured by the wealthiest sectors of the population (Hook and Howe 2005). People’s ability to benefit from the road depends largely on their initial assets: individual landholdings, livestock, and the presence and efficacy of integrated development projects. In general, only “better off communities are able to take advantage of the new opportunities [while] the poor and socially disadvantaged require additional interventions if their capacity to benefit from transport improvements is to be increased” (RAP 2003: 2). “Roads alone provide an insufficient stimulus for growth in the agrarian sector” (Molesworth 2001: 119-20): in order to make a difference roads need to be accompanied by favourable conditions and by the right policies, and access to health, social services, credit or extension services have to be guaranteed.

Therefore, this study will already contribute to the road literature in two ways. First it will help understand how people and their livelihood are indirectly affected by the environmental consequences of roads, especially by the runoff. Second it will issue recommendations as to how roads can offer more than just transport: access to markets as well improving water availability and irrigation means, therefore creating synergies that contribute to development and poverty alleviation.

Roads, water and livelihood

Water and livelihoods are intimately interconnected. People need access to clean water for drinking, cooking and household chores, to maintain their health and their dignity. Water also maintains ecosystem services, and is necessary for animal watering and crop production that make up peoples’ livelihoods (UNDP 2006). Achieving water security is key for food security and poverty reduction (Tucker, Lema and Lemma, 2013). Among others, access to clean water supply frees up time for productive activities and contributes to the decrease of water-related diseases. Having access to greater storage and retention of water may increase livestock production, kitchen gardening, and irrigation. Water also contributes to other small-scale productive activities such as beer brewing and kitchen gardening (Moriarty et al, 2004). Moreover, recent studies also show that irrigation has impacts on poverty reduction in terms of production and

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consumption, but also in terms of savings behaviour and informal insurance practices (Dillon 2011)

Water availability is even more of an issue for the rural poor who live in arid and semi-arid areas, and are subjected to high rainfall irregularity. Extreme events such as flooding and droughts also affect the productive assets and therefore livelihoods (World Bank 2006: 10):

“Flooding is a problem mainly along the riverine areas affecting productive agricultural land, settlements, and infrastructure. Flooding and sedimentation also cause damage by inundating and waterlogging productive land, encouraging growth of undesirable species, and blocking road access and trekking routes. Flooded fields often delay planting, thus reducing yields and quality of crops”.

These conditions, which are worsened by climate change, frequently lead to droughts, crop failure, reduced vegetation, fodder scarcity, and insecure water supplies (Steenbergen and Verheijen accessed 01.01.2014). In this context, increased water retention and provision can be the key to increased resilience, food and water security, and poverty reduction.

Roads and water are also clearly interconnected, although surprisingly little references can be found. When roads and water are jointly dealt with in the literature (and for engineers) it is rather about the destructive effects of runoff on the road infrastructure than the other way around. For instance: “floods and droughts cause severe damage to roads, making many roads impassable during the rainy season and even during the dry season, due to poor conditions and inadequate river crossings” (World Bank 2006: 10), or “unpaved roads are extremely vulnerable to floods, landslides, and gully erosion” (Ibid.: 25). However, roads have an important effect on the circulation of water, both surface and groundwater, and the major impacts of roads on hydrology and local groundwater availability remain little understood and rather unstudied. For instance, a Transport Research Laboratory publication mentions that roads can provoke soil and channel erosion, often increase the pressure on natural resources, and destroy agricultural land (TRL 1997). More recently, a World Bank report on Water Resources Development for Ethiopia argues that “failure of traditional road designs to integrate hydrology frequently leads to interference with downstream water use(r)s, as well as inaccessible roads” (World Bank 2006: pp. xiv), but without going into much more details. In particular, relatively little work is found on the specific effects of roads on local groundwater, for instance reduced groundwater recharge through altered surface water pathways; altered sub-surface shallow groundwater flows; waterlogging in the upstream areas, or opening springs draining some of the mountain aquifers. And therefore no work can found on the effects this may have on local people and their livelihoods: a gap remains to be filled.

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5 Road construction itself may also lead to environmental issues like pollution (waste, but also solvents, paints, oils, fuels such as gasoline, diesel oil, kerosene, lubricating oils, and grease) and sediment loadings. (Griffiths et al. 2000: 12). During the construction, the effects of a temporary labour force on the use and availability of local resources – including water - may also have to be considered.
In general, most road construction works have no provision for the storage of run-off water generated from road drainage (Nissen-Petersen 2006). Roads are often built with little consideration for hydrology, no formal Environmental Impact Assessment (EIA) is required, and “little, if any, importance is given to environmental issues during planning, design or construction,” a situation that results in “detrimental impacts not only to the natural environment but also the road and local communities” (Griffiths et al. 2000: 1). Effectively, poorly designed roads result in rain erosion to the roads, forcing motorists to pass through the fields and permanently damaging them. Cut-off channels to divert water from the road to the fields also create gullies, carry away the topsoil, and often turn fields into “a desolate moon landscape” (Nissen-Petersen 2006: ix). This way, “thousands of acres of fertile farmland are being washed away every year by uncontrolled rainwater running off roads” (Ibid.). Hence, poorly engineered road negatively affect people’s assets and livelihoods, when it would actually be possible to protect and “enhance natural water supplies and encourage the development of sustainable economic activities by encouraging retention and use of flood water” (Griffiths et al. 2000: 7).

A pioneer literature provides a comprehensive list of features that can be incorporated into road construction design to control erosion and enhance water supplies and groundwater recharge, notably “by retaining water in small dams, by maintaining a high water level that would increase the availability of water and recharge aquifers, by incorporating retarding basins to reduce runoff peaks, or by improving drainage in residential or farming areas” (Griffiths et al. 2000: 16). Although “the study of the upstream and downstream consequences of rainwater harvesting, and road runoff harvesting in particular, has started to receive attention only in recent years” (Kubberinga 2012: 15), a lot remains to be done in order to develop a comprehensive understanding of road impacts on surface and ground water flows, and how these impact livelihoods.

**Objectives of the study**

As highlighted in this section, a certain number of gaps remain in the road and water literature. Based on empirical material, this study’s objective is to contribute to filling these different gaps.

**Objective 1**

The first objective is to better understand the impacts of road on surface and ground water, and how these positively and negatively affect people and their livelihoods. More particularly, with soil erosion often considered “one of the most serious environmental problems in Ethiopia” (Shiferaw and Holden 1999: 739), and Ethiopia described as “one of the most serious soil erosion areas in the world” (Bekele and Drake 2003: 473), threatening food production and food security, the problem deserves some concern. There is a clear interest to understand how roads contribute to soil erosion, and how this could be changed.

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6 “Another hazard created by rainwater running off roads is that some people and animals lose their lives, while trying to cross a road over a riverbed flooded by rainwater.” (Ibid.)
This objective is also made more urgent in the light of current climate change predictions, which include modifications in the rainfall regime, higher probability of extreme weather events (droughts and rain intensity), and regional and food production crises. This is particularly the case in Ethiopia (McSweeney et al. 2008), an already food insecure country where changes to climate patterns are predicted to add pressure on water availability, accessibility, supply and demand (Jones et al. 2013).

Objective 2

Also, some evidence suggests that people do use roads for water harvesting, including in Ethiopia, although the practice remains limited. We call the fact that roads can serve purposes other than mobility – *multifunctionality* of roads. Through this paper, we would like to formulate general recommendations as to how roads and other integrated interventions can be multifunctional and serve needs in terms of water retention, recharge and re-use and benefit people.

Objective 3

Road design and construction processes tend to be non-inclusive. This study advocates for better inclusion of road beneficiaries and local populations into the planning and construction process, in order to serve better the needs of populations. Also, we argue that by integrating local knowledge roads could be more adapted to local specificities (geology and climate), and construction and maintenance costs could be minimized.

We believe that if these three objectives can be fulfilled – understanding road impacts on hydrology and livelihoods, building the case for multifunctional roads, and advocating for more inclusive road planning processes – then roads can be made a central tool in poverty alleviation. And by filling these three gaps, this study will help build roads that truly serve the needs of populations, and do not undermine their livelihoods.

3. Methodology and theoretical framework

Why Tigray?

There are several reasons why Ethiopia and Tigray in particular make an ideal terrain to research the impacts of roads on the hydrology, how they affect livelihoods, and what the potential of multifunctional roads could be for local populations.

The first one is the climate and occurrence of soil erosion, and the importance water has for livelihoods. The climate in Tigray is characterised as semi-arid. Mean annual varies between 552 and 767 mm a year, with erratic and torrential rains mainly concentrated during the period of June to early September and a lot of inter-year variability. These have two main consequences: the first one is soil erosion during the rainy season, with
Tigray considered as seriously degraded; the second one is water insecurity during the dry season, with severe implications in terms of food security.7

In an attempt to ensure water and food security, different water harvesting, soil conservation and afforestation programmes have been implemented, especially over the last 15 years.8 Irrigation, which has been promoted as one of the key priorities by both the national and regional governments (WSDP 2002) is expanding. Between 2004 and 2009 the number of farmers practising irrigation would have more than doubled (from 159,000 to 379,000), and the surface irrigated increased more than fivefold (from 15,000 ha to 83,000 ha) in Ethiopia (GTP 2003EC/2011). Interestingly, Road Runoff Harvesting is practised in Ethiopia, notably in Tigray where borrow pits turned into ponds are used by farmers to water their livestock (Kubbinga 2012). However, these tend to remain coincidental rather than properly planned, and wider integrated road and water harvesting/retention projects remain to be developed.

Finally, a significant road construction programme is being implemented in Ethiopia. Although the road density is considered one of the lowest in Africa, road infrastructure has been defined by the Ethiopian government as “one of the main pillars of its development policy” while rural roads are seen as “one of the decisive factors that highly contribute to social and economic development” (Emmenegger 2012: 9). Between 1997-2010, Ethiopia has implemented a large scale public investment program known as the Road Sector Development Program (RSDP), with significant results in terms of road construction and maintenance (Shumiye 2010). In a decade, government’s spending on roads was multiplied by 10 (Worku 2011). Between 2004/5 and 2009/10, the government, which has made of poverty eradication its “main development agenda” (MFED: vii) added 11,000 km of federal roads to the existing 36,400 km long network, reaching a total of 46,800 km of roads, without counting community roads (120.5 km/ 1000 km² if community roads are accounted for; see Worku 2011: 3). In 2012, the total network consisted of 114,397 km of roads (Emmenegger 2012: 9).9 Road authorities in Tigray have been approached by researchers at university of Mekelle and are interested in the potential or road water harvesting and multifunctional roads.

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7 Although we are aware of the wide-spread existence of a powerful land degradation narrative in Ethiopia and elsewhere (Keeley and Scoones 2000, 2003), its wide occurrence was also noted by participants. The elder participants often observed and showed us the physical impacts of land degradation, as well as a decrease in soil fertility: when they were young, they said, the soil was rich and everything grew easily.

8 In terms of soil conservation, a large array of techniques are used and built, mostly under PSNP: deep trenches, terraces, hill sides water harvesting, check dams, eye-brow basin, herring bone (for trees), semi-circle, percolation ponds, negari, gabion check-dam to reduce run-off speed and collect the water, or wood check dams.

9 20,429 km federal roads, 23,930 regional roads and 70,038km community roads (Ibid.). For a map of the road network, and functional classification of roads, see (World Bank 2010: 41-2). In terms of organization, Ethiopian roads are essentially governed and maintained by two different organizations: the Ethiopian Road Authority (ERA), and the Regional Road Authority (RRA.). Roads are functionally classified in 10 different standards, from DS1 to DS10 (only DS1 to DS4 are paved roads. Levels of standard are chosen based on the design traffic flow (Ibid.: 40).
The large road construction development coupled with a considerable movement to bring irrigation, associated with a significant interest in water harvesting and conservation make it a fertile ground to experiment with multifunctional roads. Recommendations that could be incorporated into current construction programmes could also be of relevance to other arid and semi-arid regions of Africa.

The Geralta Range in the region of Tigray; in the background is the road from Hawzien to Abiy Addi.

**Sites selection**

This study has benefited from the work of a team of engineering geologists at University of Mekelle, who have been working on a detailed study of the route Sinkata-Hawzien-Abreha we Atsbeha (around 50Km long) with a radius of 5Km from the main road. The survey included evaluating the geohydrology and locations of gullies. Based on this survey, a preselection of 12 sites was initially done, according to the following criteria:
- feasibility of the study (time wise an distance wise);
- impacts of runoff and formation of gullies;
- potential for rain water harvesting and re-use, and occurrence of hand dug wells and water conservation structures;
- road currently under construction, so that the ongoing process could be documented and would enable the team to research and measure its impacts on runoff, groundwater and people’s livelihoods.

Also, the different sites would offer the opportunity to look at different types of roads (highway, feeder roads and community roads), and therefore different structures (tarmac and dirt roads) and construction processes. In addition, the sites would present
different settings in terms of distance to administrative centres and geomorphology of the landscape – which happened to be an important factor in understanding the hydrological impact of roads and their consequences on the lives of people who dwell therein.

The Sinkata-Abiy-Adi road under construction

The Sinkata\(^{10}\)-Hawzien-Abreha Weastbeha-Wukro road system, situated 45 km North of Mekelle was chosen as a study site. The main road was built before 1974, was widened under the Derg regime, and is currently being upgraded into a highway to link Sinkata to Abiy Addi. This main road is managed by the Ethiopian Road Authority (ERA). Two more sections were added to our case study to include Access and Feeder roads that are respectively managed by the regional and local authorities. The following table describes the different sections of the road.

<table>
<thead>
<tr>
<th>Road</th>
<th>Technical classification</th>
<th>Functional classification</th>
<th>Administrative classification (responsible administration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinkata-Hawzen</td>
<td>-</td>
<td>Trunk road (highway)</td>
<td>Federal road (ERA)</td>
</tr>
<tr>
<td>Hawzen-Abreha Weatsbeha-Wukro</td>
<td>DS - 05</td>
<td>Link road</td>
<td>Regional road (Tigray Construction, Road and Transport Bureau)</td>
</tr>
<tr>
<td>Gule to the main road</td>
<td>DS - 10</td>
<td>Access road</td>
<td>Community road constructed through the URRAP programme</td>
</tr>
</tbody>
</table>

\(^{10}\) Also called Freiweign
Based on these criteria eleven sites were selected and ranked by order of interest (see map). Based on a pre-visit by the team of researchers, six sites that corresponded the most to our criteria were selected for detailed study:

<table>
<thead>
<tr>
<th>No</th>
<th>Location (Adindan UTM, Zone 37N) (East, North, Elevation)</th>
<th>Site condition and main reasons for selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Freweign/Sinkata area (Saese Tseaedema woreda); Coordinate: 561270mE, 1553379mN, Elev=2412m Number of househ olds affected: 42</td>
<td>The site, situated down-hill from Freweign/Sinkata town is heavily affected by the run-off from the tarmac road which is being upgraded, and by erosion and siltation which inundates and destroys fields, wells, ponds and houses. People constructed extra protection walls to minimize the impact of the run-off. The site is particularly interesting to understand the negative physical and socio-economic impacts of the construction of a paved road, and how people cope with these, individually and collectively. How to minimise negative impacts and increase positive ones can also be studied there.</td>
</tr>
<tr>
<td>4</td>
<td>Gira Aras area (Hawzien Woreda); Coordinate:</td>
<td>The tarmac road crosses a plain scattered with fields and grassland, and one side of the road experiences water logging. A borrow pit is used by neighbouring households to water cattle.</td>
</tr>
</tbody>
</table>
Table 1: Study sites

<table>
<thead>
<tr>
<th>Location</th>
<th>Coordinate</th>
<th>Number of households affected</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0553858mE, 1548608mN, Elev=2300m.</td>
<td>120</td>
<td>Number of water conservation and irrigation systems (deep trenches, lined hand dug wells) have been built. Moisture stress is a major problem in the area. The site offers the opportunity to observe positive and negative effects of the construction of a paved road, as well as the potential to integrate road construction with water harvesting and water conservation areas.</td>
<td></td>
</tr>
<tr>
<td>0541377mE, 1539142mN, Elev=2036m.</td>
<td>30</td>
<td>The unpaved link road to Abreha Weatsbeha, situated close to Hawzien, branches off the main tarmac road to Abiy Addi. The road impacts water flows, creates water logging and increases soil moisture and water recharge near an Irish bridge. Sand is collected there, but irrigated agriculture is not practised. However, people divert water from roadside drains into their farmland and runoff from the roads into deep trenches. People would like the road to be upgraded into an asphalt one considering water harvesting from roads. The site's interest resides in the opportunity to study the impacts of an unpaved road, as well as existing practices of road runoff harvesting, groundwater recharge and reuse, their effects on livelihoods, as well as potential improvements.</td>
<td></td>
</tr>
<tr>
<td>552262mE, 1534990mN, Elev=2062m</td>
<td>100</td>
<td>The site is a wide irrigated plain of green fields and wells that contrast with the surrounding dry hills. The unpaved feeder road, which has been built according to a new model piloted by the government involving small local businesses, presents a number of Irish bridges and a check dam. This site is interesting to study the potential effects of irrigation on livelihoods improvements, as well as the impact an unpaved road has on irrigation, on agriculture based livelihoods and on their distribution among the population. It also offers the possibility to understand community involvement into the process of road construction.</td>
<td></td>
</tr>
<tr>
<td>0548596mE, 1542186mN, Elev=2186m.</td>
<td></td>
<td>This area is about 5Km from Hawzien town, and the road was built by the communities (using manual labour only). The communities are highly interested to have standard road to be constructed that connects their village with Hawzien town. Community involvement into road construction and as the distance from the main road are the most important points to be studied there.</td>
<td></td>
</tr>
<tr>
<td>0557542mE, 1530520mN, Elev=2007</td>
<td></td>
<td>This site is situated on the link road between Hawzien and Wukro. Its interest lies in its well known successful water harvesting implementation that turned the area from a dry, food insecure woreda into a food secure place, and in the voluntary approach taken by its inhabitants. The kebele chairman is charismatic and very interested in trying out new techniques; including agro-ecological development. Communities want the road to be upgraded and water to be harvested from roads.</td>
<td></td>
</tr>
</tbody>
</table>

Participatory assessments (PA) and interviews were carried out in the first four locations, while detailed interviews with tabea (sub-district) leaders and villagers were conducted in the two last locations. Examples from other locations visited that were not short-listed in the study were also included when relevant.
Selecting participants

In every research location, participants and interviewees were selected so as to include:
- representatives of households that were positively and negatively affected by the road;
- male and female participants,
- representatives of different wealth groups;
- members of households that practised irrigated agriculture and others who only practised rain fed agriculture.

Further participants were chosen based on their particular experience with the road, road runoff harvesting and irrigation, because they represented a different social groups, or had been identified through focus group discussions.

Approach

This paper adopts a political ecology and livelihoods approach to the problem. Although the influences and concepts that inform our framework are numerous, it would be sacrilege to look at the political economy of land erosion without referring to the approach and tools developed by Blaikie in his seminal work (Blaikie 1985) (Blaikie and Brookfield 1987). Hence, this article, its focus and its theoretical lens are all loosely grounded in political ecology, understood as an approach that “combines the concerns of ecology and a broadly defined political economy [and] encompasses the constantly shifting dialectic between society, and also within classes and groups within society itself” (Ibid. 1987: 17). Also, noting that “there are competing social definitions of land degradation” this work puts “the land manager ‘centre stage’ in the explanation” and attempts to “learn from the land managers’ perceptions of their problems” (Ibid.: 16), and build on their recommendations.

Whenever possible, our approach leaves the simple factual description of physical processes to integrate them within chains of causality (Robbins 2004) that link facts and perceptions to their social and political causes and consequences, thus constantly oscillating between the physical/environmental and the social/political spheres. It also submits these chains of causality through to the prism of the livelihoods framework to decompose them into distinct categories: the vulnerability context in which people live; their (physical, social, human, financial and environmental) assets; their strategies; institutions and processes; and outcomes, including poverty alleviation.

This article attempts to depart from the type of “road determinism” that seems to affect part of the road literature, in which roads impacts remain largely speculative (Edmonds 1998) and are more often assumed that measured (Wilson 2004). First, we...

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11 Following Swyngedouw, “produced environments are specific historical results of socio-biophysical processes” (Swyngedouw 2009: 56), and their consequences are not neutral: some lose, while others benefit from the newly generated circulation of water. Understanding the causes and distribution of positive and negative impacts of a changed environment requires looking at power relations, discourses and practices.

12 An illustration of which could be: “The benefits of road provision are both direct and indirect. Roads create connectivity, which allows for easier access to external goods and labour markets as well as greater social contact with other settlements. This can have very powerful long-run implications and is accompanied by secondary effects on the provision of other basic goods and services” (Wales and Wild 2012: 1).
consider that roads do not create connectivity, but may improve connectivity, within a context in which people practice certain forms of mobility that often persist after the road has been built. We also look at mobility for whom. Second, we attempt to look at roads’ impacts with all their contradictions and complexity: hence not everyone is equally affected by the road, road effects remain context specific, and after the road does certainly not equal because of the road. Finally, we consider the effects of a whole range of factors other than roads, and acknowledge when their impacts may be contradictory or greater than those attributed to roads. In short, our approach attempts to identify and pin down causality chains in which roads are involved, as highlighted by stories and testimonies of our participants. We believe it is only by submitting our material to a critical evaluation that a strong case for a multifunctional approach to road construction can be built.

Regarding water, one first has to acknowledge the particular characteristics of a resource whose availability varies across time and space, and whose access to depends on technology and institutions (Mehta 2014). Our paper drifts away from purely utilitarian and economistic conceptions of water to consider a plurality of uses, experiences and understandings, and dig into ways the availability and use of water is socially mediated. Integrating the concept of hydro-social cycle, we attempt to follow and represent “the circulation of water as a combined physical and social process” (Swyngedouw 2009: 56). Departing from statements such as “Water security is achieved when water underpins economic growth rather than undermining it, or, in other words, when the net impact of water on growth is positive” (World Bank 2006) we include psychological aspects and diverse practices of production and subsistence grounded into experience of a time and place. Following Mehta, water “has different faces and meanings in the everyday contexts within which people live their lives. People across the globe value water for both its non-economic and economic roles” (Mehta 2014: 60). Water does matter for economic pursuits, especially in a rural land-based economy, but looking at water exclusively “through an economic lens […] can undermine its embeddedness in the everyday symbolic, cultural, and social contexts within which people live their lives” (Ibid.).

Methods
Our methods aim at capturing in details a plurality of individual experiences and perceptions of changes in surface and groundwater patterns strongly associated with road construction and upgrading, and the effects this had on people’s livelihoods. Of particular importance was to understand the impacts of the road (and associated runoff) on their land, cropping patterns, livestock, food security, income and non-income poverty, mobility and access, and well-being, but also how people had responded and adapted to these changes. Importantly, the tools had to capture the seasonality of these processes, as well as the way their effects and responses were geographically, socially or politically mediated.

A participatory appraisal (PA) which essentially consisted in a participatory mapping exercise, a transect walk, a wealth ranking matrix, a gender matrix and seasonal calendars, along with more general discussions on road related changes and coping strategies was conducted in four of the six selected sites. Together, the different tools
were to capture the immediate water-related impacts - e.g. flood, water loss, increased storage, retention and recharge, damaged wells or springs, waterlogging, runoff change patterns, sedimentation, etc. - and how these impacted distinct groups of households and individuals in varying ways. After the initial introduction, participants were asked to draw a map on the ground representing the road, their house, fields and well(s) or pond(s), as well as main features related to road, road runoff, water conservation and irrigation (spring, stream, culverts, deep trenches, etc.) using sand, stones, sticks, feathers, flowers, etc. Based on the map, participants discussed and explained where they would take us, and why (See maps of the transect walks in annexes). The group was then broken down into smaller clusters, often by gender, to ensure all participants had the opportunity to express themselves as freely as possible. During the walk, participants showed and explained what the effects of the road and associated runoff were, and how they coped with and adapted to them, while the researchers took ample notes, drawings, pictures, and waypoints that were later included into a Google map of the area. At the end of the walk (one to two hours), the findings were summarised and discussed in a table, along with a wealth matrix, a gender matrix, a seasonal calendar and discussions whose content was adapted to the context and used to verify our preliminary hypotheses. General results were discussed between researchers after the session.
the nine individual case studies conducted gave us an in-depth understanding and a more personal gaze into people’s life and experiences.

In order to include “different geographical scales and hierarchies of socio-economic organizations” (Blaikie and Brookfield 1987: 16), interviews with leaders and officials were conducted at the local (district and sub-district level, or woreda and tabea level) and at the regional level. Officials from the Water Resources offices and from the Agricultural and Rural Development were also interviewed. The objective was to understand perceptions, mindsets, procedures and processes related to road construction and people’s involvement at the level of road authorities. These interviews also offered the opportunity to investigate existing links between departments and probe the interest, potential and suitability of a an inclusive and multifunctional approach to road construction and planning.

![A transect walk in Gule](image)

Except for the two last sites of inquiry, the decision was made to conduct research as a team in order to adopt a similar approach and limit personal bias, to be able to discuss and fine-tune the methodology, split groups into different clusters (notably gender wise), and cross-check our data. Individual interviews (except the first one) were generally carried out by one or two researchers with the help an interpreter to provide more intimacy and cover a wider diversity of cases. Preliminary findings and hypotheses were shared and discussed within the team after each session, and field notes were exchanged, completed and verified within the group at the end of the fieldwork.
Limitations

Keeping these ambitious objectives in mind, one must nonetheless acknowledge the main limitation of the study, namely time. Despite benefiting from the expertise of a team of seven committed researchers whose experience covered road studies, water and irrigation and rural development in Tigray and Ethiopia, the short duration of fieldwork implies that seasonal variations in the rainfall regime – for instance – could not be directly observed; that only six sites were selected, therefore reducing the representativeness of the survey; and that that we had to rely on what participants were willing to tell without always being able to record alternative voices. Sometimes participants were hiding real figures for yields or cattle ownership, because it is believed it brings bad luck or because they might have expected a donation. Hence figures for yields, incomes, or livestock ownership tend to be rather conservative, whereas the amount of destruction attributed to the road sometimes tend to be inflated. For these reasons, we always privileged direct observations. Also, indirect effects such as changes in social relations, cooperation and conflicts between neighbours and other phenomena would certainly have benefitted from more in-depth and sustained methods such as participant observation over a longer time span. However, the study has also benefitted from the long preparation and extensive presence and experience in the region of four of the researchers, one of which lives in Addis Ababa, the other three hailing from and living in Tigray.

Another Limit is geographic. Regarding policy processes and public participation, for instance, it is impossible to generalise at the country level. As Keely and Scoones reminds us, the sentiment of inclusion and engagement in policy-making in Tigray are considered quite high, but “cultures of participation vary significantly across regions, depending on the relationship with those in power at the centre, and the history of interaction between people and the ruling party” (Keeley and Scoones 2003: 13-4). Hence the ability to generalise based on the experience of Tigray is limited, as it may not be representative of the whole country, although some broad lessons can be learned out of this case-study.

4. Vulnerability context, assets and livelihoods

Regional context

Ethiopia is characterised by a high degree of food insecurity, which varies across regions, seasons and households and is influenced by agroecological conditions and farming practices (Tesfay 2006). The economy is highly dependent on the agricultural sector, which accounts for 50 percent of Ethiopia’s GDP, while around 90% of the crop production derives from the peasants sector.

With less than 24% of the people of Tigray living in urban areas, the population of the research area is mainly rural (GTP 2003EC/2011). The bulk of the population relies on

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13 All interview took place between the 9th of January and the 2nd of February 2014.
14 Although our role and the purpose of the study were always stated clearly in the beginning.
a mix of subsistence agriculture and livestock raising. Crops include barely, wheat, beans, peas, lentils, teff, maize, and some vegetables (tomatoes, onion, pepper, carrots, etc.), while oxen, cows, donkeys, horses, camels, sheep, goats and poultry are owned. Agriculture is characterized by smallholder traditional rain-fed agriculture and is highly dependent on the timing and volume of rains (Devereux 2009; Tesfay 2006). It represents the main source of livelihood and economic activity for 85% of the rural population (Teshome 2003).

Following rainfall patterns, most of the rain-fed crops are planted between June and August (when 70% of yearly precipitations take place) and harvested in September (Van Den Berg and Ruben 2006). Average yields are typically low (average of 13.1 quintal/ha). The ‘hungry season’ has its peak during these months but might last 4-6 months (Devereux 2009), as our seasonal calendars demonstrate (See Annex 1 and 2 on food security and water availability). Besides climate variability, several other factors contribute to structural food insecurity in Ethiopia including low agricultural productivity, lack of off-farm economic opportunities, fragmentation of landholding and environmental degradation (Devereux 2000; Van der Veen and Gebrehiwot 2011). High rates of population growth put further pressure on availability of arable land and agriculture production. The prevalence of extreme poverty (citizens living on less than one dollar a day) was last measured at 48.5 % in 2004/5.

One of the central instruments to deal with high poverty rate and chronic food insecurity is the Productive Safety Net Programme (PSNP) introduced by the federal government in 2004. The PSNP, which operates cash and food transfers to households in most food-insecure woredas in rural Ethiopia, aims at reducing household vulnerability, improving household and community resilience, and decreasing dependence on food aid (Devereux et al. 2006). In addition to smoothing households’ consumption during the “hungry season” and preventing them from falling into destitution, the PSNP also employs people into public works to deliver productivity-enhancing infrastructure such as roads, irrigation wells and other soil and water conservation measures. While eligible households with able-bodied adults (90%) receive payments in kind and in cash for the participation of their members in public works projects, those who cannot provide labour receive unconditional transfers. Although eligibility criteria are defined at the central level, implementation guidelines allow for regional variations and community norms are used to target beneficiaries (Coll-Black et al. 2013). In Tigray, those who benefited from the PSNP received help for six months a year, in kind and/or in cash. Although PSNP wages are below market prices (around 90 birrs/month for 4 days of work, i.e. 22.5 birrs/day in Tigray), the scheme reaches people who do not have access to other forms of employment (women and elderly). In addition, each adult has to contribute 40 days of “free labour” to the community (construction, water conservation work, etc.), independently of his/her wealth status.

15 The average arable land size per household in the highlands of Tigray ranges from 0.5 to 1 ha per household (Beyene et al. 2006; Segers et al. 2010). Note that political disruptions linked to the war with Eritrea and the armed opposition to and repression by the Derg regime from 1974 to 1991) highly contributed to famines.
In order to increase agriculture productivity, reduce food shortage and tackle poverty in the country, irrigation development has been promoted as one of the key priorities by both the national and regional governments (WSDP 2002). In 2003, the total irrigated area in Ethiopia was about 160,000 hectares (WSDP, 2003), and it would have nearly doubled by 2012, at 300,000 hectares (Diao et al. 2005, Abebe et al. 2012). Whilst most of the area equipped for irrigation is concentrated in the southern regions, in Tigray the irrigated area covered around 13,000 ha in 2005 (Frenken 2005), and has significantly increased over the last decade. It mainly consists in small-scale irrigation employing traditional practices (Seleshi Bekele Yilma Awulachew et al. 2007; Hagos 2005): irrigation canals are not lined and diversion structures are constructed with wood, stones and other locally available materials (Teshome 2003). Moreover, farmers are able to irrigate not more than 30% of the land in the dry period, when the water table drops from sub-surface to 8-10 meters.

Irrigated land in Gule: the water is pumped out of wells in the bed of the river

While initial efforts to develop irrigation through micro-dams and river diversion have remained fairly limited (Seleshi B Awulachew et al. 2005; Hagos 2005), the government and NGOs further tried to spread the utilisation of other structures such as ponds and wells. In 2002, 22 districts in Tigray were involved in the Rainwater Harvesting Ponds Programme which aimed at decreasing households’ dependency on

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16 According to official data, more than 715,000 ha of agricultural land were put under irrigation (MFED: 15). The country’s potential is estimated at 3.7 million hectares.

17 It started with the establishment of the Commission for Sustainable Agriculture and Environmental Rehabilitation in Tigray (CoSAERT) in the mid 1990s.
rainfall by collecting run-off and rain water (Segers et al. 2008). In 2004, the construction of private and community shallow wells started, supported by the PSNP, one of the main food security programmes active in Ethiopia. The programme is active in the construction of shallow wells, ponds and other water harvesting structures including small-dams, deep trenches and check-dams that were all present in the research sites. As a result, the situation of soil erosion in Tigray would have improved over the last decade thanks to intensive soil and water conservation measures (Munro et al. 2008).

Another characteristic of Ethiopia, which is essential to understand the context and situations described in this study, is the land tenure regime. In Ethiopia, peasants and farmers do not own the land but are granted land use rights. Hence farmers cannot sell or buy the land, which remains the property of the state, and authorities are closely involved into its management.18 The land tenure plays a role when a new road is constructed, as the state does not have to acquire the land from the people, and compensations tend to be minimal. Since the introduction of the 1975 land reform, several periodic land redistribution have been carried out in different regions (Gebreselassie, 2006): if redistributions were frequent during the Derg regime, since the early 1990s they have been discouraged (Gebreselassie, 2006). The last land redistribution in Tigray dates back to 1991.19 Short-term rental contracts or other arrangements, which take the form of cash leases or sharecropping where a ‘tenant is entitled to cultivate a field in exchange for a fee or a share of the harvest, or both, to the land [holder]’ are common (Segers et al. 2010: 1022), and are negotiated on a seasonal basis. In Tigray, they represent one of the dominant forms of tenancy (Tesfay, 2006).20

18 The 1975 Derg land reform established that the land is a property of the state that grant land use rights to households (Segers et al. 2010). Land sale, long-term rental and permanent transfers were forbidden. The 1995 Constitution confirmed the public ownership of land and the restrictions on land transfers and sales (Crewett and Korf 2008). At a later stage, a federal law transferred responsibilities related to land management to the regional governments (Deininger et al. 2008). In Tigray Region a new land proclamation was introduced in 1997 and amended in 2002 (Tigray National Regional State's Rural Land Usage Proclamation No. 23/1997). The Proclamation endorsed the constitutional principles and introduced land certification with the aim of increasing tenure security and facilitating land transactions (Dokken 2013). A process of land registration at regional level was initiated where certification where given to land holders and rural arable lands were recorded in district register. Based on Tigray experience, since 2003 land registration has been introduced in other regions. The introduction of land certificates aims at increasing security of land tenure and thus promoting long-term investment on land improvements (Gebreselassie 2006).

19 Under certain circumstances land can be re-allocated, when a landholder die without heirs and when a landholder is absent from the village for more than two years (Haile et al. 2005). In both cases, the land returns to the tabia council who redistributes it according to a waiting list. The list includes both male and female farmers landless living in the village and people returned after the last land redistribution. The last is the case of G.M.C., who returned to Selam after spending several years in Eritrea and received land from in-village redistribution in 2010.

20 These forms of land rental occur between farmers holding lands who lack productive means (e.g. ox) or between farmers who experienced harvest failure. Vice versa, farmers who are land deficient in relation to their labour force or productive means rent in land. A study on dynamics of land access in Tigray suggests that land deals involve elderly farmers who, unable to cultivate their land, rent it to their younger relatives (e.g. children) or they include non-farmers who abandoned agriculture for other activities (e.g. handicrafts, constructions or other small businesses) and lease out their land (Segers et al., 2010). The details of the lease arrangements vary depending on the farmers, the family ties and the type and position of land (ibid.). For instance, S. M. a farmer who holds 0.5 ha irrigated land in Gulle
In terms of transport, human portage and pack animals are still the main means of transportation in the country (World Bank 2006: 23) and only 25 percent of Ethiopia’s area is served by the road transport system, mostly gravel or earth surfaced. Road density is said to be one of the lowest in Africa, and half the average road density on the continent (Ibid.: 24). In 2002, 70 percent of farms were situated more than half a day’s walk from an all-weather road. In 2010, the Federal Government planned to decrease the Proportion of Areas further than 5 km from all weather roads from 64 to 29%, and to reduce the average time to reach the nearest all-weather road from its current 3.7 hours to 1.2 hours (MFED 2010: 69) by 2015.

Wealth ranking

The wealth ranking exercise had two purposes: frame the discussion regarding the distribution of gains and losses that occurred because of the road and the road runoff, as well as identify the life conditions and vulnerability context of our participants. In general, there were very few external signs of affluence. Although houses may vary in size they look very similar, vehicles possession is null in each location studied, and the absence of electricity in all sites (except in Abreha Weatsbeh) prevents the ownership of a television set, for instance. Mobile phone ownership seems quite widespread: all participants carried one independently of their wealth status.

Wealth ranking criteria were widely similar among the different sites (except for a few differences that are explained later). The main criteria used to differentiate between the better off, medium and poor categories are months of food security and oxen ownership. The latter determine the ability to plough the land: those who do not have any ox must engage in sharecropping; those who have one ox must borrow/exchange a second one. The list of common wealth ranking criteria includes:

- months of food security
- land cultivated and access to irrigation
- livestock ownership (including oxen)
- involvement in trade versus reliance on PSNP and daily labour.
- number of barrels of tella (a locally produced fermented barley drink) that a household could provide for social events.

Notwithstanding the fact that they may not be the most relevant wealth indicator to categorise subsistence farmers, figures for monetary incomes were difficult to obtain and quite contested. In site 2 (Gira Aras), a “near-consensus” seemed to emerge around 5-10,000 birrs a year for the better off, 5,000 birrs for the medium category. At PPP (purchasing power parity), a better off household would earn between USD 998 and 1995 USD per year. For information, Ethiopia’s GDP per capita (PPP) was estimated at USD 1366 in 2013 by the IMF.

Valley engaged in sharecropping for 0.5 ha of his neighbour’s land. S. M. provides the pump and diesel to irrigate the field of the neighbour who in turn provides labour and ploughing. Eventually, they share the harvest equally.

21 and therefore of the world (LOMBARD and COETZER Year unknown).

22 The equivalent of USD 260 to 520 for the better off, and USD 260 for the medium category. At PPP (purchasing power parity), a better off household would earn between USD 998 and 1995 USD per year. For information, Ethiopia’s GDP per capita (PPP) was estimated at USD 1366 in 2013 by the IMF.
monetary income (besides PSNP) for the poor. But even these figures remained controversial.23

The surface of land a household can cultivate is a significant indicator and determinant of wealth. If the surface tenured by households is roughly similar (in theory), the main difference is in terms of cultivated/ploughed surface and access to irrigation. As Table 2 indicates the area cultivated by better off and medium households is smaller in Sinkata and Gira Aras than in Megab and Gule. Poor households are either landless or cultivate their land through sharecropping arrangements.

<table>
<thead>
<tr>
<th>Site</th>
<th>Better off</th>
<th>Medium</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Sinkata) 1</td>
<td>1 ha</td>
<td>0.5 ha</td>
<td>0</td>
</tr>
<tr>
<td>(Gira Aras) 2</td>
<td>0.85 ha</td>
<td>0.5 ha</td>
<td>0</td>
</tr>
<tr>
<td>(Megab) 3</td>
<td>1.5 ha</td>
<td>1 ha</td>
<td>0</td>
</tr>
<tr>
<td>(Gule) 4</td>
<td>1.5 ha</td>
<td>0.75 ha</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2: Cultivated land and wealth categories

As far as irrigated land is concerned, surfaces vary between locations: for the better off, from 0.35 ha in Gira Aras to 0.75 ha in Gule and up to to 1ha in Sinkata, to; and from 50 m2 for the medium category in Sinkata, to 0.25 ha in Gira Aras. In areas where irrigation is practised, the better off generally own a motorpump (up to three in Gira Aras). In Megab, there is no irrigation available, and therefore it is not a wealth indicator. This also seems to have an impact on the general level of affluence.

<table>
<thead>
<tr>
<th>Site</th>
<th>Better off</th>
<th>Medium</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Sinkata) 1</td>
<td>Up to 1 ha</td>
<td>50 m2 (0.005 ha)</td>
<td>0</td>
</tr>
<tr>
<td>(Gira Aras) 2</td>
<td>0.35 ha</td>
<td>0.25 ha</td>
<td>0</td>
</tr>
<tr>
<td>(Megab) 3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(Gule) 4</td>
<td>0.75 ha</td>
<td>0.125 ha</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3: Irrigated land and wealth categories

23 For an example of household budget for a medium-poor household, see annexes.
Other wealth indicators: In Sinkata, people gave the number of clothes owned by an individual as a marker of wealth: from four for a better off, to one for a poorer person. Also, the better off are able to buy fertilizers, whereas the poor ae not. In Megab, participants cited the type of housing as criterion: iron roof Vs hidmo (earth and straw). The better off also have three oxen, by comparison with other sites where the better off only have two. In Gule, it was mentioned that the rich can give or lend to the poor, and have a higher status in society.

Based on the data collected, particularly the difference in terms of access to land and irrigation, it seems that the better off in site 1 (Sinkata) and 4 (Gule) are the most affluent across all categories. Without access to irrigation, inhabitants of Megab are incontestably in a worse off position. Besides access to irrigation (site 1, 2 and 4), proximity of town/market (site 1 and 2) and of a main road (site 1 and 2) seem to be the important assets and could explain inter-location wealth differentiation.

The table below (Table 4) aggregates the most relevant information from the four sites where PAs were conducted. Table 5 shows the proportion of people in each category, as defined by the participants.

<table>
<thead>
<tr>
<th></th>
<th>Better off</th>
<th>Medium</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Months of food security</td>
<td>9-12</td>
<td>4-9</td>
<td>0-4</td>
</tr>
<tr>
<td>2. Livestock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- oxen</td>
<td>2-3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>- cow</td>
<td>1-2</td>
<td>0-1</td>
<td>0</td>
</tr>
<tr>
<td>- sheep/goats</td>
<td>10-20</td>
<td>0-10</td>
<td>0-3</td>
</tr>
<tr>
<td>- donkey</td>
<td>2-3</td>
<td>0-1</td>
<td>0</td>
</tr>
<tr>
<td>3. Land (ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- total land used in hectares (‘owned’ and cultivated through sharecropping)</td>
<td>1-1.5</td>
<td>0.5-1</td>
<td>0-0.5 unable to work the land (sharecropping)</td>
</tr>
<tr>
<td>- irrigated land in hectares (when available)</td>
<td>0.35-1</td>
<td>0.005-0.25</td>
<td>0</td>
</tr>
<tr>
<td>- Owns a motor pump</td>
<td>1-3</td>
<td>0-1</td>
<td>0</td>
</tr>
</tbody>
</table>

24 However, it is interesting to note that it is also in Megab that the difference in the surface cultivated land between the better off and the medium category is the smallest: the better off only cultivate 50% more land than the medium category, against 70% to 100% more in other locations.
4. PSNP

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Graduating</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Monetary income from the sell of agricultural products and livestock</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-10,000 birrs/year</td>
<td>less than 5,000 birrs/year</td>
<td>Daily labourer</td>
<td></td>
</tr>
<tr>
<td>6. Barrels of tella at social events</td>
<td>8-22</td>
<td>1-10</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4: characteristics of wealth groups

<table>
<thead>
<tr>
<th>Site</th>
<th>Better off %</th>
<th>Medium %</th>
<th>Poor %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1 (Sinkata)</td>
<td>14</td>
<td>33</td>
<td>18</td>
<td>42</td>
</tr>
<tr>
<td>Site 2 (Gira Aras)</td>
<td>20</td>
<td>17</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Site 3 (Megab)</td>
<td>10</td>
<td>33</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>Site 4 (Gule)</td>
<td>15</td>
<td>15</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 6: Number and proportion of households in each wealth group

Illustration 1: proportion of households in each wealth group
Assets

Land

With Agriculture being the most widespread occupation in the research locations, land is indisputably the major productive asset. Most households have use rights over an area of around 0.5 ha (depending on the size of the household at the time of land distribution), and sometimes engage in sharecropping over their own land or somebody else’s land. Some households have no land. As we have seen, there are discrepancies in cultivated land between households, but also large disparities in terms of fertility between the most and the less productive land. In Gule for instance, under the best conditions, the land upstream yields 2.5 qtl of barley per timad, whereas the land downstream yield 5 qtl per timad.\textsuperscript{25} The valley is a vast plain surrounded by hills and mountains and which concentrates the water and sediments, which explains the high fertility observed in the fields in the centre of the plain - where corn, tomatoes, peppers grow in abundance – by comparison to land on the hillsides. Hence at least some of the determinants of wealth are geographic, and depend on land quality and access to irrigation (see Table 7).

<table>
<thead>
<tr>
<th>How to people explain wealth differentiation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>According to respondents in Gule, people who work more and are willing to take risks (like taking a loan) end up being better off. But wealth also depends a lot on the quality and fertility of the land: those who have irrigated land earn much more than those who depend solely rain fed agriculture, especially if they can cultivate and irrigate using their own resources (and not borrowing). As a consequence, participants also confirmed that those who have land downstream in the alluvial plain tend to be better off than those who have land upstream.</td>
</tr>
</tbody>
</table>

Table 7: Determinants of wealth

Livestock

Other important assets are livestock, especially oxen which are necessary to plough the land (as well as being social status symbols). Livestock provides manure, which is indispensable to fertilize the land, but also fuel, work (oxen), transport (donkeys), and animal products such as wool, milk and eggs that can be consumed or sold on the market. Buying livestock is also an investment as those can be sold when prices are high (during the festival season for instance) or in times of hardship.

Water

The fundamental role of water as a resource and its different uses deserve a special emphasis. The first consideration is that the availability of water tends to be very seasonal, depends first of all on climatic conditions, and has widespread consequences for livelihoods in Tigray. Hence for all households relying exclusively on rain-fed agriculture (the majority of households), the rain regime and the availability of rainwater determine the agricultural

\textsuperscript{25} 1 timad = 1/4 ha. The equivalents are therefore 10 and 20 qtl per hectare, or 1 to 2 tonnes per hectare.
calendar, the timing and volume of harvests, periods of (relative) food abundance and food scarcity, as well as food prices (see Annexes 1 and 2). The rain water cycle also determines to a large extent households incomes as well as well-being, which will vary seasonally and inter-annually.

As previously seen, people’s ability to tap into groundwater somehow shelters households from highly seasonal availability of rainwater, although well’s recharge is lower from April to June. The availability of a reliable source of water all year round enables farmers to irrigate their fields and reap a steady income from the land (see Table 9 and Annex 3). If ponds enable farmers to retain water and water their fields for two more months at the end of the rainy season, (self-recharging) wells are essential to produce during the dry season, when prices are high (see seasonal calendar of water availability and agricultural production and prices in Annexes 1 and 3). The effects of irrigated agriculture are immediate in terms food security and income. Many of the participants we interviewed could be totally self-sufficient, or at least had managed to double the number of months they were food secure thanks to irrigated agriculture. Access to groundwater, which can be greatly enhanced by water conservation work to improve water retention and recharge, is not universally shared.

Access to irrigation does not seem to be precluded by the lack of human capital, knowhow or individual incentives, but rather by the lack of financial capital and most of all on geographical factors. People know how to construct water harvesting structures
and wells, and know what the benefits would be. Guidelines for construction of these structure and experiences often derive from ‘Community-based participatory watershed development” projects on-going in Ehtiopia. Many participants had worked as labourers in the construction of hand-dug wells with the PSNP. In Gule for instance, significant water conservation work had been undertaken on the sides of the valley through PSNP.

Participants in Gule also mentioned that irrigation started through individual incentives, through farmers who had witnessed it elsewhere and experimented it in their village. Then the government encouraged irrigation and helped building wells, on which farmers have individual rights. A large check dam was under construction in the bed of the river, in order to limit erosion and increase water retention and availability through shallow wells. Wells within the riverbed are used to pump water to the fields above.

In all locations and in nearly every case, water and soil conservation structures had been built with external support, as people usually lack the financial resources to provide the construction material on their own, as in the following account:

H. lives in Gira Aras. Thanks to the well situated next to the road, H. is able to irrigate half an hectare of land, and produce for the market as well as ensure at least 8 months of food security a year. The hand dug well was built by the Millennium Villages Project in 2010, with the help of a contractor, and is shared by 6 farmers; 10m wide and 8m deep; because it was constructed on his land, H. has the prior use right in case water is getting scarce; at the moment, it is used for 1 day and then left to recharge for 3 days; the 6 farmers maintain the well together; each farmer has an individual pump, which they use to irrigate 4h/day, 8 days a month; there are 30 wells across the road, also built by the Millennium Villages Project. H. could also buy his pump thanks to a loan from the Millennium Project.

In Megab, there are very few wells, so that irrigation is not practised. This seems to be due to the sandy nature of the soil and therefore the very deep water table, too deep to be exploitable for agriculture. The availability of water for irrigation depends above all on geological factors. This was confirmed during interviews with experts from the Woreda office who mentioned the availability of groundwater as one of the criteria for hand-dug wells location.

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26 Managing Environmental Resources to Enable Transitions to more Sustainable Livelihoods (MERET, which in Amaric also means land), for instance, is one of them. MERET is a programme implemented in several woreda within the whole country (Abreha-Weatsbeha was included in the project). It puts together rural development and enviromental protection. MERET is similar to PSNP, but it focuses mostly on soil and water conservation measures through community based integrated watershed management approaches. Through a participatory planning process the community design the watershed management plan and define the actions needed to deal with soil erosion. The project includes capacity building in relation to soil and water conservation.

27 Gira Aras is located close to Koraro (Hawzien district), a village chosen by the Milenium Villages Project (MVP) managed by the Earth Institute, the United Nations Development Programme (UNDP) and Millenium Promise. Although the aim of this paper is not to assess the MVP – and this is one of the very few times the projected was mentioned during our fieldwork – the achievements, principles and most of all the poor evaluation of the project have recently come under criticism, notably by the work of the journalist Nina Munk and her book The Idealist (2013).
How is water used in agriculture?

The water is used before ploughing to soften the soil, after seeding to irrigate the seeds and young sprouts (water stress at this period kills the crop), and during growth as the use of irrigation increases the yields (up to double). The water is diverted to the fields when required, and diverted along the road to the river when water is not necessary or too abundant.

Different mechanisms are in place, both informal and formal, to allocate water between users. For instance, in Gule formal Water User Associations have been introduced. These are in charge of dealing with allocation of water for irrigation purposes between several users within one hand-dug well. Meanwhile, in Megab, water harvested from the road is divided by farmers cultivating nearby the road through informal agreements.

Table 8: How is water used in agriculture?

For drinking water, people usually use the closest hand pump, which can be situated up to one hour walk away as water from springs and runoff is generally unfit for human consumption: in Sinkata for instance, the water coming from the hill (and town above) is full of rubbish and human waste. In Megab, a hand pump lies in the middle of the community grazing land. The pump, which was built some 20 years ago by the government, is used for drinking purposes. It is protected by a stone enclosure while a 20-meter long channel carries the runoff to a pond sheltered by an acacia tree, where donkeys and cattle are taken to drink. People living downstream use another pump. For other domestic purposes (washing clothes) people use a spring nearby.

People complained that the number of pumps for drinking water in the area was not enough. In Megab, the pump is used by around 200 households, so that those in charge of fetching water (usually women) have to queue for up to two hours. If added to the time spent commuting (some would walk up to two hours for a return trip to collect water at this point), the task is enormously time consuming. The amount of water that can be collected is also wealth dependent: those who has two donkeys can carry four jerry cans (25 L each) in one trip, i.e. 100 L, whereas someone who has no donkey can only carry 25 L.

Work opportunities

Especially for landless and non-food sufficient households, work opportunities include construction work (houses and roads), carpentry in urban areas, or agricultural labour (ploughing, watering, weeding, harvesting, hay collection). Many households depend on the Productive Safety Net Programme (PSNP), which provides households with cash and grain for 6 months a year (from January to June) in exchange for 4 days of work per month per registered member. Each adult also has to contribute with 40 days of

28 The hand pump in Megab is managed by a five members development group who is in charge of maintenance, fees collection and managing savings. Users ay a fee of 3 birs/month.

29 As previously explained, there are also PSNP targeted member, usually elders and disable people, who are targeted and dispensed from work obligations.
voluntary labour a year for communal works, but this is unpaid. In general, work opportunities tend to be very seasonal as those are dictated by the agricultural calendar (for agricultural work) or happen during the dry season (construction work – see Annex 5). Irrigation also increases work opportunities beyond the rain-fed agricultural season.

Financial capital

As previously mentioned for most households monetary incomes tend to be low and financial capital is therefore limited. External support was always required to undertake major works, build a lined well or to acquire a pump for irrigation. Some individuals had access to loans through credit cooperative.

Social capital

An essential institution is the development group. The group, which was introduced 4 years ago by the government, has a well-defined structure consisting of a chairman, a secretary, a spokesman (vice-chairman) as well as 20 to 28 households. Development groups are responsible for managing communal land: enriching the grazing land, clearing of stones, and controlling access and enforcing the “cut and carry system” f.30 Separate groups are in place to regulate the use and access to hand pumps, for instance.

According to participants, solidarity mechanisms between households are fairly limited and closely related to social status and wealth. When asked how they would cope with an extreme event that would affect their family, like the flood of 2004, participants would first answer: “the government (mengesti) is responsible. Our community should help each other, but it cannot due to limited assets, so it is the role of the government.” Second, if the government is not in a position to respond, respondents said they would have to migrate. If only one household is affected, the community could help by providing straw and grain, although the support depends on the social capital, status and kinship of the household. As a participant in Megab confirmed, if she had a husband with a high status, people would help her; but in her situation she would get no help: “I would have two options: migrate, or die.” Those who are member of a saving association can also take a loan.31 An interviewee mentioned that she bought sheep thanks to such a loan and sold them during festival times to repay her loan.

If solidarity mechanisms and labour sharing groups did exist in the past, and richer households used to lend grain to poorer ones, these would have been significantly weakened by the fact that even relatively well off households are not food sufficient anymore. This would explain why, as it will be seen later, people tend to rely more on individual than collective coping mechanisms. For instance, in case of fields siltation there is no or little cooperation between households. The same happens with collective land, if protecting the land from erosion is not included within the list of duties of the group. In numerous cases, participants mentioned they would turn to the state, which tends to be very present in regulating communities’ affairs.

30 The cut and carry system was introduced some 6 years ago by the government and has been enforced for the past 3 or 4 years.
31 Each member saves 50 birrs a month, in exchange of what they are entitled to take a loan at 10% of interest.
Seasonality

As it has been in rural Tigray, the vulnerability context is characterised by high seasonal variability linked to climatic factor. As previously highlighted, rainwater availability, yields, food security, prices, work opportunities and incomes are all very seasonal (See Annexes 1 to 6). The climate has also some effect on health (see Annex 4), as malaria, common cold and diarrhoea mostly occur during the wet season, while eye disease are more common during the dry season.

5. Road impacts

Our first encounter with the Sinkata-Hawzien-Abreha Weastbeha-Wukro road started in Sinkata. Just after branching off the main highway and its impeccable tarmac - good enough to organise a bicycle race on that day – and crossing an grid like urban zone of small and colourful ground floor houses that had been half destroyed to make way for road enlargement, we found the road to Hawzien, a large dust road that winded down the hill until it reached the plain, crossing through the landscape of scattered houses and dry fields in a near straight line towards the horizon. The few vehicles (mainly construction trucks and a few occasional busses) lifted dense clouds of fine dust. The steep slopes above and below the road was devoid of vegetation, and the gullies that formed after each culvert showed the clear signs of erosion. We were told that the road had been built under the Derg regime in 1976 to replace the existing track (the bridge on the way to Hawzien had been built by the Italians during the occupation). Culverts were added around 1983, leading to increased erosion downstream. In 1992, the road was widened to a 15 meters width and covered with asphalt, leading to more precious land lost and increased erosion. Since the road had been widened last year, erosion had increased and was threatening houses.

"Others do benefit, but there is not a single benefit this road has brought us."

If this statement translates exasperation with the authorities' lack of reaction in face of the erosion and of the high probability of a coming disaster in Sinkata (see later) rather than an objective evaluation of the situation, the fact is that for the people of Tigray the road comes with blessings and curses which tend to be unequally distributed. As another participant later summed up “We believe that roads are good for the community, but we are affected by the road runoff, erosion and floods.” People are positively and negatively affected by the road, and the distribution of positive and negative effects differs between households and individuals.

In this section, we first attempt to describe the direct impacts of the road, second the impacts of the road on the hydrology and how people cope with them (coping strategies and adaptation), and third the consequences these impacts have on people's livelihoods and well-being. Finally, we will investigate how impacts are distributed and coping strategies and adaptation capacities differ between individuals and households. This first sub-section examines the impacts of roads per se (summarised in box 10). The impacts are classified as positive or negative, based on perception of the men and women interviewed during the PAs.
The road being upgraded below Sinkata. The road generated a lot of erosion and siltation during the rainy season.

Impacts directly related to the road

<table>
<thead>
<tr>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Easier Transportation and use of vehicles</td>
<td>- Land lost to the road, to the service road, and to the borrow pit</td>
</tr>
<tr>
<td>- Access to ambulances (for childbirth and other health issues)</td>
<td>- Compensation too low in relation to the loss of livelihoods and level of dependency on land</td>
</tr>
<tr>
<td>- Access to markets to sell goods, resulting in more cash crops being grown</td>
<td>- Fields compacted by construction trucks</td>
</tr>
<tr>
<td>- Better circulation of price information</td>
<td>- Dust, which makes people sick and dirty, affects crops and reduces fertility of the fields</td>
</tr>
<tr>
<td>- Better access for <em>tabea</em> and <em>woreda</em> services (Agriculture extension and health services)</td>
<td></td>
</tr>
<tr>
<td>- Road construction provides employment</td>
<td></td>
</tr>
<tr>
<td>- Use of vehicles</td>
<td></td>
</tr>
<tr>
<td>- Asphalt roads reduce the amount of dust</td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Physical impacts of the road

In all locations, participants noted that the most positive aspects of road construction were access to hospitals and health centres, and the ability to call an ambulance in case of emergency. This change, which went hand in hand with the better provision of health

32 Due to road upgrading, from dirt road to asphalt road.
services, is especially important for pregnant women, at time of delivery. In Gule, One female participant recalled: “I delivered twins: one was born on Tuesday, the other one on Wednesday. If the road had already been built my pain would have been over in a day.” They also mentioned the case of a woman who died in labour the previous year in the neighbouring village of Erub, “because there is no road access.”

Second, it was noted that road transport offers access to markets and allows people to sell wood and agricultural products. Better transport options during market days enabled them to sell in Wukro, Dugum, Hawzien and Megab; and thanks to the road there is also better information flows on market prices.33 “Tomatoes for instance are difficult to transport to the market by donkey;” they can now be transported by truck. The road also facilitates the acquisition of agricultural inputs, as the company now comes and delivers pumps, seeds, fertilizers and pesticides directly to the village. By comparison, in unconnected villages those have to be carried by donkey. Partly as a consequence of the road, irrigation has expanded, and participants mentioned they had witnessed significant transformations in the village: “Ten years ago, we had only rain fed agriculture. Now, irrigation enables us to have up to three harvests a year, the productivity has increased, with positive consequences in terms of income and nutrition. […] We need infrastructure: roads, electricity, transport…”

Also, with the road government services have become closer: from two days, to two hours from Abreha we Atsbeha to Wukro. It also makes the work of officials easier: as a health extension worker in Gule told us: “now we are connected to the rest of the country.” And in Megab more tourists come and visit the area (the village is the access point to troglodyte churches higher in the Geralta Range).

Finally, road construction provides employment. This is mostly the case on smaller roads whose construction tends to be more labour based. Near Sinkata, a Federal road, the Chinese construction company employed only young people from the village, around 18-20 years old; elder women, for instance could not participate. In Gule – because it is a community road – there was also overlapping between the upgrading of the road and the PSNP programme; women were employed through PSNP. Employment of young people (at 30-50 birr per day) was ongoing on other stretches of the road.

At the same time, people also reported negative impacts linked to the road, the main one being the loss of agricultural land due the construction of the road and associated structures: borrow pits, embankments and secondary road notably. This was particularly resented, since in most cases people who had lost land on which they heavily depended for a living had not received any compensation;34 and each time the road was upgraded people were losing more land. As A., a women from Sinkata told us:

I have seen 3 phases of road upgrading: every time I lost some land, but I have received zero benefits. Others have, but not me (...). Some land was lost to the first road in 1976. The culvert was added in 1983, leading to erosion downstream. In

33 Note that many sell their crops at the time of harvest or in December, and later buy them back when they are short of food, selling animals. Lack of storage issues could be an issue.
34 A compensation was given for the land taken by the secondary road in Gira Aras: between 400-700 birr.
1992, the road was widened to 15 meters and covered with asphalt, leading to more land lost and more erosion. No compensation was paid, and this explains why we are left with only 0.5 ha.

Another problem was the production of dust, especially during the phase of road construction but also later in the case of dirt roads. The thin dust, which reduces the visibility to a few meters every time a car or truck passes, makes people sick and dirty, affects crops (especially during harvest time), and decreases the fertility of the fields. This is why people were in favour of upgrading roads to tarmac roads, which would enable them to remain “as clean as an Italian bride” (Sinkata).

Dust lifted up by trucks and cars in Megab

**Impacts linked to the changing hydrology**

In the twelve sites visited, among all impacts attributed to the road, the effects of the runoff were by far the most observable ones, often spectacular, although not always predictable. Roads tend to increase the runoff, divide watersheds, redirect the runoff, and redistribute water across the landscape. These physical impacts can have positive and negative consequences for the land, fields, wells, ponds and ultimately on people’s livelihoods. These effects may vary seasonally and are affected by the geography as well as the intensity of rains. We start with the negative effects, before looking at the positive ones.
Physical impacts, coping strategies and adaptation

a. Negative impacts

Before the road was upgraded and elevated, water spread relatively evenly across the land; but the elevation of the road led to a concentration of water upstream and along the road, so that the water runs off through the culverts or where the slope's gradient allows it. In two places, culverts have created gullies down the road, while in a third place another gully has formed as the water flows along the upper side of the road and into peoples' houses and fields and threatening them.

One of the main impacts of the water coming from the road is land degradation. Erosion and siltation make the fields difficult to cultivate and sometimes useless (they indicate a piece of land where sediments coming with the run off make the soil hard and difficult to cultivate). A lady explains that cactuses were planted along the canal in order to control the erosion, but even cactuses are damaged by siltation. People also constructed soil bounds to protect their houses from the runoff. In some cases they asked for help from the woreda, and the Chinese (the construction company) came with machines. The contractor dug a trench at the third gully to protect the houses, but it has not been effective and is already silted after less than a year. In other cases they had to give up the land to create some protection for the house... For the people, these structures are “a matter of survival.”

(Abstract from Rossella’ field notes, Sinkata, 9th of January 2014)

In this location, a large area of fertile land had been lost due to the construction of the road and its embankments, the service road and the borrow pit. Talking only about the borrow pit, eight households had lost some of the their fields, some up to a quarter of their land. Although there were talks by the contractor of restoring the land, it was pretty clear that the fertility of the soil could not easily be reclaimed. Also, erosion could be observed on the edges of the borrowpit – as the runoff was washing away part of the thin and dark layer of top soil – which farmers tried to prevent by constructing small mounds. Similarly, the secondary road built for road construction was full of stone and mud, and it was obvious that it would be difficult to cultivate that land again, if they ever got it back....

(Abstract from Jon's field notes, Gira Aras, 13th of January 2014)

As these two field notes abstracts show, people who live near the road have to face varied physical consequences of road and road construction, whose impacts seriously affect their assets. People use a variety of adaptation and coping strategies to protect themselves from the runoff and repair the damage due to it. Of all locations visited, Sinkata was undeniably the most affected one, with gullies up to 4 metres wide and 3 metres deep forming on the downside of the road. The gullies carried flows of water, mud and garbage during the rainy season, threatening fields and houses downstream. The causes were certainly geographical, linked as they were to the large catchment area, steep slopes and large patches of barren land between the village and the road that concentrated the runoff over a large area and into a small bottleneck. But causes were also social and political, linked to the road and its upgrading, to urban extension above, and to conscious and unconscious decisions made by planners and engineers and
desperate measures taken to shelter from the floods. The road had been elevated; the single culvert inside the turn had been replaced by three culverts in order to get rid of the increased amount of water that could damage the road; and the land above had been stripped naked and heavily terraced to make space for the road. Although last year’s rains had been relatively few and less intense than on a typical year, the impacts of the runoff on fields and houses had worsen. Most of all people feared for the coming years: with more culverts and more rain, people expected the impacts of the runoff to be disastrous and feared for their lives and livelihoods.

A gully formed after a culvert in Sinkata

The strong runoff coming from the road had flooded the fields and houses downstream. It had infiltrated into houses, washed away the mortar, provoked the subsidence of the soil, eroded the walls and weakened them, and in at least two cases led to the complete collapse of houses. Similarly, the runoff carried away the topsoil of fields. As it reached less steep areas, the mighty runoff transformed into floods of stagnating water, leaving large areas waterlogged, decreasing people’s mobility and risking contaminating groundwater around hand pumps. Deep gullies also hindered people’s and livestock mobility, and in the case of Gule often caused cattle to break their legs in the thick, steep and slippery clay gully walls.
The silt carried by the runoff was also responsible for siltation of ponds, compost pits and wells, but also of fields which were rendered difficult to till and sterile. In Sinkata, the increased runoff also carried the garbage coming from urban areas, particularly during the first rains (people from Sinkata town discard their garbage down-hill, just above the road). Women were afraid of needles and condoms that deposit on the grassland downstream and which cause a threat to both people and cattle. The water also carried excrements, while large flooded areas downstream favoured the outbreak of waterborne diseases and malaria. In other areas, the runoff carried oil and mud from the road to the fields.

In Gira Aras (Site 2), the situation was slightly different, as the elevated road in the wide plain blocked the flow of surface and ground water, resulting in one side being water logged and the other drier. The negative impacts were also due to the 12 ft large service road that ran parallel to the main road. As it was higher than the fields, it prevented the water from flowing through the culvert. As road are upgraded, they are often elevated, up to two meters higher than the field. Therefore roads have more effects on the circulation of the runoff. In some places, the culvert was accidentally closed by stones that fell during the construction, while in other places the contractor had built mounds to protect the service road from the runoff: this increased water logging in fields and resulted in a loss of fertility due to the combined effect of salinization and anaerobiosis. The loss of fertility also seemed aggravated by soil compaction caused by road construction trucks. As a result, over the last two years crops of teff and barley that
were planted in affected field did not grow well, if at all. Farmers consequently lost their investments in seeds and inputs, and their harvests and incomes had decreased.

Coping strategies

People who have to deal with road’s impacts on changing hydrological regimes essentially have to cope with two types of situations: having too much water, or not enough of it. One also has to differentiate coping techniques that are used to deal with immediate effects of the road runoff, from longer-term strategies.

Hence, people could develop waterways and dig trenches to divert the water to the farmland if they wanted to irrigate the land, or away from the farmland if there was too much water. In the later case, people could drain the fields by building furrows and trenches. Water conservation structures like deep trenches were also built to increase water recharge, although these were always undertaken collectively through PSNP. When built upstream, they could reduce the runoff; downstream, they could reduce the occurrence of waterlogging.

A common way to limit erosion and contain the flood was to build mounds of soil or stones in front of walls, fields and houses. People were also commonly planting cactuses (of two different types), agaves and eucalyptus trees. This was rather done individually to protect one’s own field: in Megab for instance, a clear difference existed between individually managed land which were bordered with cactuses, and collective land that
were devoid of cactuses and prone to erosion (the gully there was up to 1.60m deep at that place). In Sinkata, planting cactuses to contain erosion was supported by the PSNP.

In Gule, where the area downstream of the road and of the ford was severely eroded, forming a gully 10 meters large and up to 5 meters deep, the community had filled the gully with stones and gabion to stop the erosion. And next to the ford was a reforestation area where community members had planted eucalyptus trees to attempt to stabilise the land and retain the topsoil. A check dam was also under construction downstream to limit erosion, increase groundwater retention and irrigate the fields. Such measures were efficient, but necessitated more material resources than what people usually have. Hence an external contribution as well as tabea coordination was required.

In Gira Aras, because the flow of water is obstructed by the service road, the amount of water available for the grazing land is less than optimal, resulting in less animal fodder available. Potential effects and coping strategies identified included having to buy fodder, selling cattle, or giving less food to animals (which may die).

People also had to cope with destructions generated by the runoff, for instance re-ploughing and re-sowing what had been washed away, clear off the silt, and as a last resort abandon the fields. As a result of waterlogging and runoff, people grew crops that were less valuable in the market but more resistant: crops with longer stems such as maize, sorghum and finger millet. People also had to clean the silt from other productive assets such as wells, ponds, compost pits, trenches and furrows, and rebuild houses,
sometimes changing the location of openings so as to be less affected by the next flood. When dealing with destructions, people could also use collective action and legal mechanisms: In Sinkata, 42 affected households (represented by three persons from the community) went to court to complain of the effects of the runoff. A petition was passed on to the woreda and from there to the regional and federal court (people were still waiting for a decision at the time of fieldwork). The sub-tabea leader also said that the government arranged compensation for those who had to move because of the road – a total of 1500 birr (approximately $75), although they had not received anything yet, and no concrete solution had been suggested. In Gule, some people affected were attributed new land in compensation.

Participants indicate the height of the water during the floods

b. Positive impacts

As a participant in Sinkata once mentioned “Having more water run-off is bad during the rainy season, but more water in wells is good during the dry season,” so that negative effects at one time of the year could become positive at another. For instance, at the entrance Gule, one finds an Irish bridge which was constructed by a contractor with the help of the population (the material was provided by the tabea while the community built the gabions to protect the bridge). The gabion structure was washed away by the runoff three times during the construction process, and people noticed that since the bridge was protected there was more runoff during heavy rains, causing heavy
erosion downstream. On the other hand, the bridge had also increased moisture and water retention upstream, and people were able to divert the water to irrigate their fields. In that case, the situation had improved thanks to the road.

In Gira Aras, the increased run off from the road had a positive effect on the moisture of grazing land downstream, which had become greener. The higher quantity of runoff had also increased the recharge of hand dug wells used for livestock watering and irrigation: four hand dug wells had seen an increase in recharge, and obviously the aquifer had been replenished since the water level in wells was about two metres higher. Many more wells were built in the area under PSNP in order to benefit from groundwater available.

Sometimes, combined effects could be observed both upstream and downstream. In Megab, an Irish bridge had been built to cross a seasonal stream while sand had accumulated behind it, acting as a sand dam. The bridge had increased and spread water retention and moisture upstream, benefitting the cropland. By doing so, it had also decreased and regulated the amount of peak run-off, making it more even across time. While the area used to be severely degraded and had developed huge gullies, the area above and below had become greener and more forested than before. Trees were planted or grew spontaneously, and grass started growing so that more fodder is available. Later, the cut and carry system was introduced, while deep trenches had been built to increase groundwater

35 The participants suggested a lower Irish bridge to limit the amount and concentration of run-off; or a high bridge to that the water flows freely.
recharge, measures that also contributed to improve the situation. A hand dug well was currently being built upstream in order to irrigate the fields around (water was visible in the bottom). There was also a water pond downstream that was used to water the livestock, but it was said to be very contaminated and had a lot of insects breeding. In Megab the construction of the road and Irish bridge had very much benefitted the area.

In relation to erosion, there were also cases, like in Megab, in which the concentration of runoff through culverts had resulted in reduced erosion and less siltation of the fields. Road structures that channelize the runoff also led to clear improvements in terms of accessibility. In Gule for instance, before the ford at the centre of the village was built, the river could remain impassable for three to four hours in a stretch, dividing the village into two and preventing access to the school. Now that a bridge is constructed people can cross the river safely nearly at any time of the year.

**Positive adaptation**

In several cases, people have also positively adapted to the augmented runoff. In Gira Aras as well as other locations, the run-off from the road and from the area adjacent to the road is canalised through a small trench and small stack running parallel to the road until its lowest point (the location of the blocked culvert). The water can be diverted to the fields, or further to the grazing land where deep trenches have been cut to increase groundwater recharge. This has resulted in increased moisture in the grazing land and increased water availability in wells. The system was even more elaborate in Megab,
where a trench parallel to the road is lined at the lowest end with stones and interrupted by a gate system to direct the water to the field or downstream along the road in the direction of the culvert.

In several places, the augmented runoff was captured and used to recharge the aquifer through shallow and deep trenches dug into pastures. Although the trenches had been built under PSNP prior to road upgrading, they are one possible adaptation mechanism that could be put into place to benefit from the increased road runoff.

In places where the runoff was too important and floods and silt damaged people’s assets, deep trenches and other water conservation measures could be built, and in combination with the road and bridges also helped reduce the runoff, limit damages and recharge the aquifer. For instance in Megab the situation had improved since a culvert, had been built 20 years earlier, resulting in more concentrated runoff and therefore in less water flowing onto the fields and less siltation.\(^{36}\) The situation had also improved thanks to water conservation measures taken on the hills above, which reduced the runoff. Similar tendencies were noted elsewhere.

In other places, it seemed the potential for irrigation and improvement had been missed. For instance in Megab a small trench bordered by trees runs nearly parallel to the road. The engineers built the trench to protect the road, but people are not allowed to use it to irrigate the fields as “it could result in more water running on the road and damaging it,” as a participant explained. Hence the water, which flows directly into the gully, remains unused. In Sinkata, since there is no reservoir, people are not able to retain some of the formidable runoff that flows down the slope, and which could be used to irrigate their fields. In Gira Aras, people used to harvest road run-off in some places, but they “cannot use it now because the situation is different:” The elevated road had lead to hydrological changes, and the water does not flow anymore. People have to adapt to the new circulation of water, surface water as well groundwater, or “the visible and invisible effects of the road” as a participant explained during the PA.

<table>
<thead>
<tr>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Flooding and waterlogging upstream, and decreased moisture downstream (negative effects on fields, grazing land and livestock)</td>
<td>- Increased runoff from the road and adjacent areas is canalised to the fields and pastures; as a result fields benefit and grazing land downstream is enriched; forest cover has also increased</td>
</tr>
<tr>
<td>- Runoff redirected and concentrated in culverts, leading to increased and accelerated erosion, formation of gullies and floods downstream</td>
<td>- Road runoff harvesting and groundwater recharge through ponds, deep trenches and shallow wells</td>
</tr>
<tr>
<td>- Siltation of fields, ponds and wells</td>
<td>- Increased groundwater available in wells for irrigation and increased fodder for livestock</td>
</tr>
<tr>
<td>- Obstruction of culverts during construction and during rains due to siltation</td>
<td>- Increased moisture downstream (in some cases)</td>
</tr>
<tr>
<td>- Elevated road and service road blocking the even flow of runoff</td>
<td>- The water table downstream is more stable throughout the year</td>
</tr>
<tr>
<td>- Increased runoff leading to the destruction of crops, and the loss of seeds, fertilizer and</td>
<td></td>
</tr>
</tbody>
</table>

\(^{36}\) This was also visible from the large amount of sand carried away by the seasonal stream and obstructing the culvert. The culvert had to be cleared regularly, or the water would flow over the road during the rainy season, inundate and bring sand and silt into the fields, and affect the crops.
seedlings
- Waterlogging and siltation (clay) decrease the fertility of the land and make it more difficult to cultivate
- Waterlogging increases the incidence of malaria
- Loss of arable land due to road, gullies and infertility of the land
- Increased runoff carrying the garbage from town
- Oil and mud from the road transported by the run-off to the fields.
- Damage to houses: water infiltration, collapse of walls, soil subsidence, and mortar washed away
- Hand pump’s apron damaged by runoff and floods, making water unsafe to drink
- Invasive species carried by the run-off and growing in peoples’ fields

- Borrow pits can be used to store the water
- Diversion of rainwater from erosion gullies to fields
- Sand concentrating in gullies
- Yields at the hand pump increase
- Possibility to cross the river during heavy rains

<table>
<thead>
<tr>
<th>Table 10: summary of the positive and negative impacts noted</th>
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</table>

Livelihoods impacts and well-being

Negative impacts on livelihoods

“The flood went through the house, the family had to pack their belongings and run to a higher place until the flood subsided; now every night that there is rain, they need to be prepared to pack their belongings, take their animals and go out to an elevated place or to neighbours to shelter; this is particularly difficult for women who just delivered, small children and older people. They reinforced the walls of the house to minimise the effects of the flooding, which comes first as a flash flood that can be up to 1.5 meters high and then longer standing water of about 50cm; they also changed the position of the entrance door of the house to protect it from water running inside. Behind the house, the compost pits are half filled up with sand (siltation) […]

“When a strong flood came, one year ago, the ground under the house subsided and led to the wall partly collapsing; the sleeping/living room was destroyed and the family had to move to a different area of the house; while they have collected stones to rebuild it, they have not yet been able to carry out the works; the owner fears that in the next rainy season, the flooding will be much worse. If nothing is done, they said they would have to abandon the house.”

(Abstract from Katharina’s field notes, Sinkata, 9th of January 2014)

As the previous field notes’ abstract illustrates, physical impacts of road runoff have wide reaching consequences in terms of livelihoods and well-being, first of all because they affects people’s physical assets. But they also impose on people a financial burden, as people have very limited resources to rebuild or cope with roads impacts, protect or rebuild their assets. Moreover, as people fear for their lives their well-being is seriously affected.

First, people have to deal with lost or damaged assets: not only those destroyed by the road for which they often received no compensation, but also those damaged by the
runoff, siltation and waterlogging - fields, house, ponds, livestock lost, etc – on which agrarian based livelihoods depend. Second, agricultural inputs that were washed away by the runoff have to be replaced. In Gira Aras, a farmer had ploughed and sowed expensive high yield varieties (1000 birr/kg), and twice they were destroyed by the flood. In Sinkata, it was estimated that in case of complete harvest failure in one field a farmer would lose the equivalent of 50,000 birr per hectare if planted with wheat, and 30,000 birr per hectare if planted with teff at market prices, and several months of food security depending on the size of the family. There were also losses due to farmers shifting from high yielding varieties to more resistant but less valuable crops, resulting in smaller harvests and inferior incomes when sold on the market.

Households also have to bear additional financial and labour costs to repair houses, empty ponds and wells, re-plough the fields, or repair other assets. Sometimes people had to plough and sow their fields 3 times because their seedlings had been washed away by the flood. In Sinkata, a farmer had had to repair twice the front and the back of his house that collapsed over the last three years (the last time after the upgrading of the road, although the rains had been relatively weak): it did cost him a total of 7000 birr in addition to his own work. The same person also had to build a wall to protect his lined hand dug well from siltation, although he still needs to remove the silt every year. Collective assets such as the apron of the hand pumps that had developed cracks would also have to be repaired to limit contamination risks.

People’s well-being is also affected in other ways, such as by reduced mobility and waste of time resulting from floods, waterlogging, unusable assets (such as silted ponds and wells) or from the formation of deep gullies that become impassable for humans and livestock. In Sinkata, between September and February, when ponds are silted those who do not have lined hand dug wells have to walk one hour away to water the cattle. There were also health threats due to the garbage and excrements transported by the runoff, and increased risks of waterborne diseases, notably malaria, due to water stagnating in fields. Since people’s life is also at risk (house collapsing and children washed away in gullies and canals), the effects are also psychological: in Sinkata some people cannot sleep at night because of the fear of flooding. As T., a lady from Sinkata told us, when it starts raining she stops her activity and runs home as she is worried about what could happen to her house, family, and cattle. She dreams they could have a house in a safer place: “If we would receive new land, she says, we would not stay here one more minute.”

Issues related to road runoff also impact social cohesion. Conflicts arose between the two communities of Sinkata and Dinkishe in relation to the management of the canal and of the run off: they fight physically and brought the case to court. A mediator was appointed by the tabea to help the farmers cooperate. In Gule, the Development Agent (DA) also mentioned that there were more and more water related conflicts among farmers, which required mediation on behalf of the authorities. He attributed them to

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37 Respectively $2560 and $1540.
38 Altogether, he spent 2000 birr on labour and a total of 5000 birr on lunch, tella, and coffee. In addition to his work, he employed two workers for eight days each for the back of the house, and six people for one day for the front.
the increased vegetable production, which requires additional water. For instance, “last week, a farmer came to complain, because a neighbour was taking too much groundwater and therefore he emptying his own well. There was not enough water for the two of them. Everyone understands the importance of irrigation.”

**Positive impacts on livelihoods**

As previously explained, physical impacts of the changed hydrology can also be positive, and some households’ livelihoods have also benefited from better access to resources and improved assets, thanks to the road. In Gule when the road was built people who lost land were allocated new stretches of land in compensation. While in general new fields are less fertile than the old ones because the area was previously uncultivated and the land is stony and untilled, people have benefitted as some of the newly allocated fields are now irrigated by the runoff of a nearby spring.  

In several locations people benefitted from the road runoff to water their fields, with positive effects on yields and incomes, although these effects were sometimes marginal. Where the runoff and moisture had increased, grazing land had also become greener and produced more fodder to feed and fatten animals. Another positive effect noted in Gira Aras was the possibility to use the large borrow pit – which recharges at its lowest point – as a water retention structure to water the livestock: water cows, oxen, donkeys, sheep and goats.

The most notable improvement on livelihoods came from increased groundwater resources, i.e. when the runoff can be collected, stored in the aquifer — for instance through deep trenches and sand dams — and re-used during the dry season. When the amount of groundwater is available in sufficient quantities, people are able to irrigate their fields. As a result, they produce more and can cultivate during the dry season. In Sinkata and elsewhere, people benefitted from the increased recharge of lined hand dug wells, which now yielded up to two or three additional barrels a day. Participants noted the potential of more groundwater available for irrigation: someone who only grows 8 qtls of grain on a hectare could easily grow 15 qtls in one harvest with irrigation. Hence yields are double. Moreover, those who irrigate are able to harvest two times a year - sometimes even three - including during the dry season when prices are higher. They are also able to produce higher value crops. As a participant mentioned, “the one who has access to irrigation will always be food secure.” In Gira Aras where the runoff is directed through a culvert towards deep trenches, the water is harvested through a large hand dug shallow well. The water is used to irrigate the fields around, as well as a small plant nursery (see illustration). For people of Gira Aras, ground water recharge and shallow wells are “the most important and sustainable solution,” a solution to which multifunctional road infrastructure can contribute.

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39 Five households who were allocated land share the run-off from the spring. They have informal byelaws on how to distribute the water, maintain the channel and manage the spring, without any external intervention. The fields bordering the road are covered with pepper and thistle, a nitrogen fixing plant whose seeds are also used for cooking.

40 Although the water was said to be contaminated by the high density of cattle
Roads’ impacts and changed hydrology also benefited new and non-farm based livelihoods, such as sand collection. In Megab, since the culvert concentrates the runoff through the gully, sand also deposits there. The gully downstream of the road is used for sand collection, which generates livelihoods in the village. Four cooperatives of 28 members each (members belong to the youth association and are essentially school dropouts from land-less households, from different *kushets*)\(^{41}\) are entitled to collect and sell the sand that accumulates in the riverbed, as long as it does not damage/erodes’ farmer’s plots.\(^{42}\) The following table summarises the effects of roads on livelihoods.

<table>
<thead>
<tr>
<th><strong>Negative</strong></th>
<th><strong>Positive</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Loss of assets (fields, house, ponds, livestock, etc.)</td>
<td>Livelihoods impacts:</td>
</tr>
<tr>
<td>- Increased costs for agriculture due to the loss of inputs</td>
<td>- Increased groundwater for irrigation and increased production: higher yields, more and bigger grain, more straw</td>
</tr>
<tr>
<td>- Financial and labour costs to repair houses, empty ponds and wells, re-plough the fields, etc.</td>
<td>- More grass collected for livestock</td>
</tr>
<tr>
<td>- Floods and Waterlogging decrease peoples mobility; deep gullies become impassable for humans and livestock</td>
<td>- Increased agricultural and livestock production resulting in improved food security and higher incomes</td>
</tr>
<tr>
<td>- Health threats due to transport of garbage</td>
<td>- Borrow pits can be used to water the livestock.</td>
</tr>
</tbody>
</table>

\(^{41}\) Neighbourhoods, a subdivision of the *tabea*.

\(^{42}\) There are 4 collection points in total, and each cooperative is entitled to use them (cooperatives usually take turns). Profits are divided between members who receive around 50 *birr* each for a whole truck, while the sand is exported to Wukro and beyond to feed the booming construction industry.
(notably needles and condoms) excrements by the runoff and risk of waterborne disease (malaria) from water stagnating in fields
- Siltation of common pond result in people without wells having to walk further to water the livestock
- Psychological effects: people live in fear, cannot sleep when it rains out of fear for floods
- Concentrated run-off and high level of water in the canal are dangerous for children
- Conflict between communities in relation to the management of the canal and of the run off
- Sand concentrating in gullies can be harvested, providing extra livelihoods

<table>
<thead>
<tr>
<th>Table 11: Positive and negative impacts of the road on livelihoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who is impacted?</td>
</tr>
</tbody>
</table>

As our car zoomed at high speed on the perfectly engineered large and slick tarmac road to Sinkata on a Saturday morning, one could not miss the hundreds of people walking on the side of the road carrying pots, bags, baskets or chickens or dragging oxen and goats to the weekly market. And as we passed the market and approached the top of the hill, we realised it was thousands of people who converged on the city, sometimes covering huge distances and carrying heavy loads on the head. If buses are few and
transport expensive, walking is undeniably the way of transportation for the vast majority of people, which leads us to ask “whose road is it?” As people mentioned, the road has huge advantages for the community. The road benefits all, “Roads are a prerequisite for other development activities” as a participant said; but whereas rich persons can go by car and have easier access to transportation services, others have to walk. Rich people have donkeys, whereas the poor have to carry crops, goods or water.

Naturally, the distance from their house and fields to the road – principally a main road – is one of the aspects that influences people’s ability to use the road. But access to transport is also differentiated according to wealth, as for the vast majority of people transport remains expensive: a return ticket from Sinkata to visit the hospital in Wukro (a mere 35 km away on the highway) would cost 25 birr, for instance. Participants established that the rich could travel 3 times a year to Wukro, whereas the poor could only go once a year, and may have to sell assets to pay for the trip. Few buses are available, and the service tends to remain limited from town to town. Walking remains by far the most common means of transport, even over long distances, except when heavy loads need to be carried. The price of transport also prohibits daily labourers and wageworkers from commuting. Yet, as a lady in Megab explained people do manage to use the bus free of cost to deliver foods and small items to their relatives in town, passing on the goods to a passenger in the bus.

Regarding the effects of the road on surface and ground water and on livelihoods, these are not equally distributed either. Participants noted that the impacts of the road are first of all geographically distributed, and that they tend to hit or benefit the rich, medium and poor in the same way. Yet coping strategies and the ability to adapt differ between wealth groups.

For instance, poor and rich can collect the road runoff. The ability to divert or remove water from the fields is the same for everyone, and depends above all on the location of the field and on the terrain. When floods and siltation happen, those who are situated closer to the road, and especially closer to culverts and gullies tend to be the most affected (See maps in annexes: the arrows represent the runoff). People were also more affected in Sinkata where the slope is steep and the land barren, and therefore large quantities of silt are carried away by the runoff. The possibility to store and re-use water also depends largely on physical factors such as the geomorphology and geology of the place. In Megab there were attempts to introduce ponds, but due to siltation they could not be used much, and wells were generally not built, due to the nature of the soil. Hence the first important factor in order to benefit from the new hydrology is geographic.

However, coping and adaptation options also depend on financial, human and physical resources available to the household. For instance, it was found that poorer households with low food security are proportionally more affected by floods than richer households who have more resources to rely on. Whereas the poor need external support from the government through PSNP or from relatives, the rich can live and cope without external support. The wealthiest have access to a pump, to a well, and to
material (cement) to construct a well. They also have more social capital when it comes to mobilising the work of others.

The better-off also tend to have a wider array of options available to them. A better-off person can hire daily labour to work on water conservation works (e.g. digging trenches), use more fertiliser and plough up to four times, build stronger protections around their houses, react without delay (e.g. rebuild a house within a short period of time) or rent another place if their house is damaged. In comparison, poorer persons have to do the work themselves (which has an opportunity costs), can only plough their fields twice, use only little fertilizer, cannot remedy a problem quickly, cannot protect themselves so well from flooding, and cannot rebuild their house because they have no savings to pay for labour and material.

In terms of reaping the benefits offered by irrigation, the wealthiest are also likely to benefit the most. The better-off can afford a pump, buying fuel, fertilizer and extra-labour, which are all expensive.\(^{43}\) With the use of fertilizer, water requirements are also higher, and water is said to be insufficient. Hence, there is a tendency towards an accumulation of benefits attributed to the road to the better-off. Those who have access to irrigated agriculture can produce vegetables and off-season, which they can export thanks to the road, and therefore become better off. Moreover, there is a risk that the administration tends to reinforce this bias. Since the agriculture department and its officials seek to maximise agricultural output, when choosing the location of wells, the priority is given to farmers that already have a pump, and highly productive land. Those receive precedence over the use of the well.\(^{44}\) This could favour the better off farmers, without concerns for equity or poverty alleviation.

However, one unexpected finding concerns the impact of irrigation on the landless. If “the allocation of state-controlled resources in rural development […] usually disfavours the physical and social margin” (Blaikie and Brookfield 1987: 18), it was discovered that those who had been excluded from land distribution could actually benefit from irrigation and associated gains in agricultural productivity.

G. lives in Megab. He is landless, because he was working as a daily labourer in Harar and was absent when the last land redistribution took place in 1991. He has no access to the grazing land, no livestock and no poultry. Yet, G. does cultivate land through sharecropping arrangements.

G. has access to credit, and once took a loan from Dedebit (at 15% interest rate) to buy an ox. He used the ox to plough and cultivate one \textit{timad} (a quarter of an hectare) in sharecropping, thanks to which he managed to produce enough teff and

\(^{43}\) Because of the costs, people were sometimes wondering whether the use of intensive agriculture made sense.

\(^{44}\) According to officials, the location of wells depends above all on the hydrogeology and on the potential for recharge. In Wukro, it was described to us as “a technical issue: it depends on groundwater availability, whether the area is cultivated, the potentially irrigable land, soil type, and returns should be at least 38 quintals of grain for 3 hectares; if less, it is not worth it.” Wells are also shared among a number of farmers, at least in theory; but in practice several wells were used by a single farmer. It is also agreed that if groundwater is insufficient for all users, then the owner of the land on which the well is located has the priority over others.
wheat to be food sufficient for four months. The arrangement was that he would provide for all costs (seeds, labour, fertilizers), and would keep half of the harvest for himself. He managed to feed the ox with straw, grass from roadsides and weeds collected on others’ fields, but had to sell the ox after the harvest as he was unable to feed it and had to repay the loan (being denied access to pastures). He bought the ox 5000 birr in May, and sold it 4700 birr in November, when prices are lower. It was a success and he intends to do the same this coming year.

Would he benefit from irrigation in Megab? Since there is no irrigation in the village he cannot comment. It could help him if he had 2 oxen, but in any way it is too recent for him to have an opinion. The spread of irrigation in Dugum – a nearby village included into the Millennium Development project – has no impact in Megab: “there is a lot of poor people there, so they are the ones who get more work”. After thinking more about it, he thinks irrigation in Megab could also help him, by creating more demand for labour, and through sharecropping arrangements.

As the experience of G. shows, the landless could also indirectly benefit from land-based interventions such as irrigation schemes, under the condition that they have access to credit (or sufficient financial capital) and access to sharecropping arrangements. Yet, the strategy implies a certain risk, a large investments (money and labour wise) and it is likely that the landless will benefit proportionally less than farmers with tenure rights. However, the experience is worth mentioning, and how such interventions could be made to benefit the landless more should be investigated.
Road impacts also have a gender dimension. It is a known fact that women (as well as elders and young ones) tend to be more vulnerable to climate change linked events and shocks (Nelson 2011). During our fieldwork as well, in case of flood, weak people (women, children, old) were found to suffer more because they are less able to resist the flood: “When there is a flood, women and children are not able to leave the house and die.” Men, women and youth are also likely to be affected differently by changes in hydrology and water resources, according to the separation of tasks within the household. Whereas irrigation is usually mostly done by men, collecting domestic water tends to be done by women, and watering the livestock by children, wells, ponds and hand pumps will affect them differently whether they are intended and used for irrigation, domestic water supply or watering the cattle. This can have tremendous effects that are distributed along gender lines. As Mehta reminds us, the world over “cultural norms dictate that women and girls are responsible for water collection [...]. This time instead could be used to focus on livelihood and agricultural activities and also improve maternal health and that of infants [or] to attend school”45 (Mehta 2014: 59). This, in turn, can also affect the wellbeing of the entire household.

In terms of taking advantage of new opportunities offered by increased runoff and groundwater available, it was also found that single headed households are at a disadvantage:

45 “and enjoy a normal childhood” (Ibid.)
B. is a single mother who lives in Gira Aras with her two children (one daughter and one son), her brother and his family. She lost land when the side road was constructed during the road upgrading process, and some of her land (around 20 x 40 m) is affected by waterlogging because of the elevated service road. As a result, she estimates she loses around 150 kg of grain every year. In 2011, a lined hand dug well was built on her land, next to deep water trenches. The well recharges well and could potentially be used for irrigation. Unfortunately, she cannot cultivate, as her brother suffers from noma and his unable to plough the land.

Hence, her ability to take advantage of new opportunities is constrained by gender relations (ploughing is customarily a male task) and the disease of her brother. Not only did B. lose because of the road, but she also lacks the human and social capital that would enable her to restore the productivity of her land and irrigate her fields.

The following table sums up the conclusions from PAs. It shows that the better-off have relatively more options than the poor when it comes to coping from the impacts of the runoff and floods. As a consequence, the better-off tend to be more resilient to the effects of the run-off than the poor, while the poor tend to be more affected, without possibilities to react or to adapt.

<table>
<thead>
<tr>
<th>Better-off</th>
<th>Medium</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Can hire daily labour to work on water conservation works</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Can use standard fertiliser and plough up to four times</td>
<td></td>
<td></td>
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<tr>
<td>- Can build stronger protection at their houses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Can react quickly (e.g. rebuild a house within a short period of time)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Can rent another place if their house is damaged</td>
<td>- Can employ Labour and work themselves</td>
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</tr>
<tr>
<td>- Plough 3 times</td>
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<td></td>
</tr>
<tr>
<td>Use non-standard fertiliser</td>
<td>- Have to do the work themselves (opportunity cost)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Can only plough 2 times</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Can use only little fertilizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Cannot remedy a problem quickly</td>
<td></td>
<td></td>
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<tr>
<td>- Cannot protect themselves so well from flooding,</td>
<td></td>
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<tr>
<td>- Cannot rebuild their house because they have no savings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12: Coping strategy matrix according to wealth status

6. Participation and planning processes

In Tigray, as in many other parts of the world, the shape of roads - straight lines with angular turns and grid patterns - seems to symbolise planning processes: in most cases, roads are imposed on the landscape and on the people without much local consultation. And as it came out from interviews with officials, communities in general are little involved in the decisions concerning the design of the roads. Design represents a technical activity reserved for experts from the woreda offices, regional or national roads departments. This was also confirmed by participants in villages, according to whom there were no consultations by authorities or contractors during the planning phase. However, since the agency in charge of road construction depends on the classification of roads, levels of public participation in decision-making depend on the type of roads built.
Requests for new roads or road upgrading are said to originate from the *tabea*, and demands are transmitted to the *woreda*, to the regional bureau, and to the Ethiopian Road Authorities (ERA), although the criteria are set and the final decision made by the highest authority. Before the construction or upgrading of the studied roads, community meetings were held to illustrate the road project and to promote the road construction with the community (to ‘motivate’ the community). But most of the time, participation was limited to a contribution in labour: with free labour (20 days community free labour) or paid daily labour (food for work, PSNP, or employed by the contractor). As M. in Megab told us:

Initially the government gathered the whole community to communicate the construction of the road. The government officials promoted the road as a way to improve the livelihoods of the people, as it would facilitate access to markets. The people asked for a compensation for the ones who would lose land due to road construction. The government officials answered: ‘our government is poor’ and they highlighted that land is the property of the government. Eventually, people did not receive any compensation for the loss of their land. Nowadays, the people in the village are murmuring that ‘the Chinese’ (referring to the Chinese company that is constructing the highway) give compensations to the people for the loss of land. Villagers are a bit unhappy.

In some cases the *Woreda* would have contacted the road authorities regarding specific issues – sometimes related to water and erosion– but they said there was hardly any response. One reason may be that roles and responsibilities in relation to roads construction, design and monitoring activities are divided between different institutions depending on the road classification; and the higher the classification, the more difficult it is for people and their *tabea* to contact the relevant authorities. Another reason could be that integration and collaboration between different departments (including bureaus and *woreda* offices) in relation to road is rather limited at all administrative levels (although it tends to be more frequent at *woreda* level, where roads and water were part of the same office until 5 years ago). At the regional level, there is no collaboration between the Tigray Bureau of Water Resources, Mines and Energy (BoWRME) - responsible for construction of borehole, shallow wells, hand-dug well, small and big dams, and river diversions - and the office in charge of water and soil conservation measures, or the bureau in charge of road construction (Mekelle).

This lack of collaboration also precludes the integration of hydrological considerations and irrigation needs within road design and construction processes. According to officials, what happened was more adaptation in reaction to a changing configuration due to roads than concerted planning. For instance, after the construction of the road, adaptation happened in the form of soil and water conservation structures and water harvesting in Megab and Gule: deep trenches or tree conservation areas next to Irish bridges were an adaptation by government offices and local communities. In fact, road authorities and contractors seem mostly concerned with protecting the road and getting rid of the water (with limited considerations for those living downstream). And if potential negative impacts of the roads in relation to the environment (landscape, water resources management, etc) are supposed to be assessed through Environmental Impact Assessments (EIA) and EMSF (Environmental and Social Management
During the design phase, it is not clear how far their recommendations are included into the design and put into practise during the project development phase. Opportunities linked to water harvesting from roads are not included in the road design guidelines, and thus are not taken into account in the design process. Moreover, most of the time experts did not ‘see’ them. There were exceptions, however, at the woreda level, where engineers and experts did observe the increase in runoff and mentioned its potential use for “spate irrigation” (Wukro).

There were cases in which the road infrastructure was damaged because engineers and contractors did not take people’s knowledge, perceptions and recommendations seriously into consideration. For instance, in Gule the main bridge was damaged even before the contractor handed it over. According to participants the bridge should have been higher and consist of six culverts rather than three. During heavy rains, the bridge is flooded as the water passes 50cm above the structure: it damages the bridge, makes it impassable, and further erodes the fields downstream. The villagers had mentioned that three culverts would be insufficient given the amount of water, but their warnings were ignored.

In fact, it is likely that increased community participation and inter-sectoral collaboration into the planning and construction phase would lead to better roads that would really serve the needs of the people, decrease the amount of runoff related damage and increase rainwater harvesting opportunities. As the episode about road construction in Gule shows, road authorities would also benefit from integrating local knowledge and people’s suggestions into the design: this would also lead to more adapted structures and lower construction and maintenance costs.

Overall, it appears that community roads (Rural road – Design standard 10) - i.e. rural community roads that connect kushet to kushet and kushet to tabea - offer a wider potential in terms of multifunctionality and rainwater harvesting. Physically less disruptive, communal produce less destructive runoff. In terms of planning process, since the demand originates at the tabea level and is dealt with at a local level, people tend to have a better access to decision-making centres and therefore on the road itself. At woreda level, decisions concerning the road and water related infrastructures and involving the PSNP) are discussed within a Steering committee that consists of representatives of the road, water, environment, youth and women offices. Issues are addressed by the local authorities. After the construction, it is also the community that is in charge of road maintenance. Some projects even involve a money contribution from the communities to increase their ownership of the project. Another interesting initiative is the Universal Rural Road Access Programme (URRAP), under which the government engages fresh university graduates and local small-scale contractors to build roads and reduce unemployment. The community is consulted and the tabea leader takes parts in decisions for non-technical matters.

Such a project was taking place in Abreha we Atsbeha, a tabea of 919 households situated 20 kilometres away from Wukro and notorious for its strong leader known by his war name as Abra Wani and its successful use of water and soil conservation.

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46 We were told that these documents cannot be accessed.
measures. We visited the village as an 8 km-long irrigation canal was under construction through PSNP and voluntary labour. The dirt road that crosses the village and was constructed in 1994 but had never been upgraded. The road, which is managed by the regional road office, is included in the URRAP programme which also finances its maintenance. Abra Wani strongly asked for the upgrading of the road to asphalt. He even talked to the vice-president of Tigray region, who promised him that the design of the new road will be ready in 2015 and the road upgrading will start in 2016. The leader is involved in the design of the road and do consult people “if it is necessary.” In one case a farmer had to give up a part of his land due to the community road construction, and he gave him another piece of land as a compensation.

Canal construction in Abreha we Atsbeha

However, this experience contrasted with the initial construction phase, when people at the tabea level were not consulted. The road had negative impacts, to which they had to react and adapt. The water that concentrated into the culvert caused erosion, gulling and loss of farmland downstream. People managed to turn these negative impacts into positive ones: downstream of each culvert they constructed structures to harvest the water flowing through the culvert and from the road. They used this water to irrigate fields, grazing land and plantations or let it percolate through deep trenches. In one site a new spring opened, which they use to their advantage. Other structures include check dams and ponds. The community did not receive any external help: the people contributed with free community labour. They now receive help from the woreda: cement and mesh for the gabion.
By contrast, activities organised through PSNP tend to be more standardised. In order to define which are the priority activities that they submit to the woreda for funding they use the manual provided by PSNP and consider “the interest of the community.” The woreda committee (15 members) defines the priority activities. The woreda leader then submits a plan to the committee; the plan is discussed, modified, approved and implemented. During the construction, the leader appoints ‘activity leaders’ in charge of directing the works, organizing the farmers and supervising them. For instance, for the construction of the irrigation canal, the leader divided the labourers into three groups. Each group is supervised by a management committee consisting of three members (one directly reports to the leader, two support the coordination of activities and division of labour). They also make use of informal networks.

In Selam, a tabea situated 5km away from Hawzien and connected to it by an earth road, the current road was constructed 12 years ago to replace a track used by people and donkeys. When the current road was constructed, the location and direction of the road was modified to the current one. As the vice-leader explained to us, the community was consulted regarding the new location of the road. Meetings were organized, and he thinks that the community fully participated in the decision through development groups and the network system. The road was constructed mainly through community free labor and through the food-for-work program. As the road crosses several communities (kushets), each kushet contributed with labour. The construction of the road lasted 20 days. The woreda coordinated the whole construction process, whereas woreda experts were in charge of the technical design of the road.

When the road was constructed, the villages also faced problems linked to the run-off that negatively affected the road and the farmland downstream of the road. To solve the problems soil and water conservation structures were introduced upstream. The people from the village contributed to the construction of these structures within the 20 days of voluntary labour, and built deep trenches, and soil and stone bounds. Hand dug wells were also built, sometimes with credits from the government. Decisions concerning the location of hand-dug wells or other water harvesting structures followed two main criteria: availability of water, and presence of alternative options and food security status. Hence poverty and vulnerability was also taken into consideration in the selection process.

In Selam, there are no public transport facilities, partly due the low quality of the road and low population density. Yet people do benefit from the road, as it facilitated the construction of a health centre in the kushet. The road also improved access to government services and to the court. Thanks of the presence of the road, the farmers are also able to sell their products before the harvest, at the so-called ‘farm get price’, as retailers come directly to the village to buy the product before it is harvested. Villagers used to suffer of post-harvest losses, now they can sell their products more easily, and the price of commodities has improved.

The processes at play in community road building and water and soil conservation measures at the tabea level, as described here, rely on a great part on leaders and experts. These processes certainly happen within a setting characterised by power configuration and are not exempt from village politics, although we did not have the
opportunity to investigate these in details. However, the devolution of decision making and responsibilities and the stronger community participation do ensure that more appropriate decisions are made, in terms of mitigating the effects of the runoff, adapting and harnessing potential of water harvesting, and that these decisions are made for the greater benefit of the people, with some consideration for equity and poverty alleviation.

Positive trends are also observed at the administration level. In terms of cross-sectoral integration for instance, the new “interface approach” started by the government attempts to create an interactions between the different offices, although it remains limited. Also, training organised by University of Mekelle had an impact in raising awareness about road linked negative impacts and potential. Experts of the Bureau of Agriculture and Road Development (BOARD) at the regional level mentioned that “now the experts within the BoARD are aware of the problems and challenges related with road and water (e.g. siltation, erosion, gulling). They also increasingly consider the opportunities for water harvesting.” An expert from the regional office of BoWRME also told us: “until now, the road only represented a barrier. Now the situation has changed as he has started looking at roads as an opportunity for water harvesting” (Mekelle).

7. Conclusions and recommendations

The construction of roads modifies the physical landscape. By doing so, it imposes a reorganisation and redistribution of the hydrological (surface and ground water), geological (erosion, siltation) and socio-economic processes (location and movements of goods and people). For people who inhabit the landscape, roads have positive and negative impacts, which are physical and whose distribution is first of all geographically determined, notably by the geomorphology and hydrology of the place (weather regime, gradient of the slope, type of soil, size of the catchment area, etc.) and by the trajectory and structure of the road. The impacts of roads and water run-off on peoples and on their livelihoods, and people’s ability to influence these physical processes, adapt to these new geophysical processes, grab new opportunities or cope with their impacts depend in turn on political and institutional mechanisms, on which people tend to have very limited control. This is more especially the case if the road is a major infrastructure managed by a centralised body far from farmers’ reality.

As the numerous examples from this study illustrate, roads are often planned and built with insufficient consideration for surface and ground water flows. As a result, these often have deleterious effects on the assets and livelihoods of people who depend on them, notably because of the devastating effect of the runoff. But properly planned roads – associated with simple engineering techniques – can also be used to direct surface run-off, collect and store water and recharge aquifers. By providing extra water and sheltering rural dwellers, farmers and herders from floods, droughts and irregular rainfalls, such techniques have the potential to tremendously improve the life and livelihoods of the rural poor in arid and semi-arid regions of the world. And because people are often knowledgeable of local conditions and of their needs, they should be consulted and their knowledge should be integrated into the planning process. Rather
than being coincidental, if generalised, multifunctional roads and better community participation could contribute to poverty reduction and to a more equitable use of shallow groundwater resources.

The examples of road rain-water harvesting, or soil and water conservation measures and wells built next to a road show that roads can help increase the availability of water. However, such occurrences tend to be quite coincidental: they should be generalised. Roads have to be thought planned and built as multifunctional infrastructure, and serve needs in terms of water retention, recharge and re-use and benefit people. Also, better inclusion of road beneficiaries and local populations into the planning and construction process is necessary in order to serve better the needs of populations. By integrating local knowledge roads could be more adapted to local specificities (geology and climate), and construction and maintenance costs could be lowered. By understanding road impacts on hydrology and livelihoods, by building multifunctional roads, and ensuring more inclusive road planning processes, we believe that roads can be made a central tool in poverty alleviation.

**Recommendations**

1. Systematically include Environmental Impact Assessments and Social Impact Assessments in the process.
2. “Take account of design changes which concentrate or speed up flows, lower the water table, or increase flood risks” (Griffiths, 2000: 5).
3. Consult people during the planning and construction process (see box) by introducing formal consultations and take local knowledge into account.
4. Include guidelines on how to harvest water from the roads in the Design Standards of all roads from highways to feeder roads and in the guidelines on Participatory Watershed Management.
5. Support on-going training efforts in relation to roads and water harvesting and promote cross-sectoral workshops or trainings to enhance collaboration.
6. Initiate formal consultations and/or collaboration processes between different sectors at regional levels and support current on-going efforts at woreda level: road construction, water management, agriculture and PSNP.
7. Compensate the loss of assets, if possible with land allotment.
8. Provide material and financial support to help to people cope and adapt to roads, to runoff and to the potential of irrigated agriculture.
9. Integrate a watershed approach to limit runoff and siltation (case of Sinkata) and include the totality of ecosystemic changes triggered by road construction.
10. Include multiple ways to harvest water and soil and water conservation techniques in road design
11. Turn borrow pits into rain harvesting ponds (use chlorine to avoid contamination/water born diseases); if possible, create several borrow pits spread around the road and in useful areas rather than one single one
12. Further promote the use of local resources (material, capital and labour) and pursue labour-intensive methods to benefit communities by maximizing employment and income creation

**Recommendations from participants:**

- "Before conducting any intervention in rural areas, the authorities should consult the people who live there. Local communities should be included into decision making”. Also, the contractor should consult people in the *tabea* because they have knowledge about the land run-off in general in the area. Local expertise should be included into road design.
- When problems occur, the authorities should respond immediately
- When there is no ground-water available, water harvesting and storage is necessary
- The government needs to design proper water management facilities and provide different sources of water for household consumption, irrigation and livestock
- The government should compensate for lost land
- Runoff from the mountains should be collected
- Tarmac rather than dirt roads should be built, due to the problems of dust
Annexes

Glossary and key terms

*birr*  Official currency of Ethiopia. Exchange rate as of Jan 2014:

BoARD  Bureau of Agriculture and Road Development

BoWRME  Bureau of Water Resources, Mines and Energy

EMSF  Environmental and Social Management Framework

ERA  Ethiopian Road Authorities

Irish bridge  causeway, ford

*kushet*  neighbourhood

*mengesti*  the government

MERET  Managing Environmental Resources to Enable Transitions to more Sustainable Livelihoods; *meret* also means land in Amharic.

PSNP  Productive Safety Net Programme

RSDP  Road Sector Development Programme

*tabea (tabia)*  lowest administrative tier in Ethiopia, equivalent to a sub-district

*teff*  local cereal

*tella*  locally produced fermented barley drink

*timad*  Measure of land

URRAP  Universal Rural Road Access Programme

*woreda (wereda)*  second lowest administrative tier in Ethiopia, equivalent to a district

Seasonal calendars
Annex 1: Food security (no irrigation) and food prices in Sinkata

Annex 2: Food security and rain water availability in Megab
Annex 3: Food security and agricultural output with irrigation in Gule

Annex 4: Seasonality of diseases

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47 Main diseases include: cough (dry season), common cold, eye diseases, skin diseases, diarrhoea, and malaria (rainy season).
Example of household budget: A. in Sinkata

**Income:**

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tala (local beer)</td>
<td>80 birrs/month</td>
<td>(3birr/L)</td>
</tr>
<tr>
<td>Cow food</td>
<td>100 birrs/month</td>
<td>(by product of Tala)</td>
</tr>
<tr>
<td>Eggs</td>
<td>64 birrs/month</td>
<td>32 eggs/month</td>
</tr>
</tbody>
</table>
PSNP (4 persons targeted) 360 birrs/months (6 months) 90 birrs/pers/months for 6 months per year*

Woreda parliament membership 70 birrs (3 months)

Son’s daily labour 1020 birrs/month (6 months) 70 birr/day, around 4 days a week from Jan to June

Total 244 to 1694 birrs/month

**Expenditures**

<table>
<thead>
<tr>
<th>Category</th>
<th>Monthly Amount</th>
<th>Yearly Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>Up to 1500 birrs/month</td>
<td>1000 birrs/year</td>
</tr>
<tr>
<td>Cloth</td>
<td>83 birrs/month</td>
<td>1000 birrs/year</td>
</tr>
<tr>
<td>School</td>
<td>31 birrs/month</td>
<td>140 birrs/year (uniform and books) 9 birrs/month (fees)</td>
</tr>
<tr>
<td>Health</td>
<td>58 birrs/month</td>
<td>700 birrs/year</td>
</tr>
<tr>
<td>Labour (harvesting)</td>
<td>208 birrs/month</td>
<td>2500 birrs/year</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>125 birrs/month</td>
<td>1500 birrs/year</td>
</tr>
<tr>
<td>Transport</td>
<td>0</td>
<td>(last year, 3 times to hospital, 26 birrs for a return ticket)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>515 to 2015 birrs/month</td>
<td></td>
</tr>
</tbody>
</table>

* PSNP entitled persons receive 90 birrs/month for 4 days of work, i.e. 22.5 birrs/day, and Atsede is entitled to 16 days of work (4 members). This is below market prices, but people who do not have access to other forms of employment (women and elderly) usually accept; also, people are often paid for a particular task (e.g. 10 metres of trench), so that a working day is often 3-4 hours. Usually, old people are “directly targeted” and do not have to work. In addition, each adult has to contribute 40 days of “free labour” to the community (construction, water conservation work, etc.)

Note that there are important variations in terms of income and expenditures between months with food security and monetary income, and those without, when food and fertilizer must be bought (and food prices are high). It is difficult to get a yearly figure due to variations in terms of prices, because participants tend not to keep a track their budget, and because they tend to voluntary under-estimate and hide their income and assets (for instance, Atsede declared 5 sheep but we counted 7). Considering that A.’s household is food secure for 3 months a year (food expenditure: 0), has to buy food at low price for 7 months (500 birr/month), and high price for 2 months (1500 birr/month), the household’s yearly expenditure can be estimated at 12,560 birrs a year, for a total income of 11,418 birrs a year. The difference could be made of additional days of labour, or sale of agricultural products or fattening of cattle (during festival times when prices are high).

Estimation of yearly income/expenditures:

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<thead>
<tr>
<th></th>
<th>per month</th>
<th>nb months</th>
<th>year</th>
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70
<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Price</th>
<th>Total</th>
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<tbody>
<tr>
<td>Tala (local beer)</td>
<td>80</td>
<td>12</td>
<td>960</td>
</tr>
<tr>
<td>Cow food</td>
<td>100</td>
<td>12</td>
<td>1200</td>
</tr>
<tr>
<td>Eggs</td>
<td>64</td>
<td>12</td>
<td>768</td>
</tr>
<tr>
<td>PSNP (4 persons targeted)</td>
<td>360</td>
<td>6</td>
<td>2160</td>
</tr>
<tr>
<td>Woreda parliament membership</td>
<td>70</td>
<td>3</td>
<td>210</td>
</tr>
<tr>
<td>Son’s daily labour</td>
<td>1020</td>
<td>6</td>
<td>6120</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>11418</td>
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**Expenditures**

<table>
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<tr>
<th>Item</th>
<th>Quantity</th>
<th>Price</th>
<th>Total</th>
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<td>Food low</td>
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<td>7</td>
<td>3500</td>
</tr>
<tr>
<td>Food</td>
<td>1500</td>
<td>2</td>
<td>3000</td>
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<tr>
<td>Cloth</td>
<td>83</td>
<td>12</td>
<td>996</td>
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<tr>
<td>School</td>
<td>31</td>
<td>12</td>
<td>372</td>
</tr>
<tr>
<td>Health</td>
<td>58</td>
<td>12</td>
<td>696</td>
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<tr>
<td>Labour (harvesting)</td>
<td>208</td>
<td>12</td>
<td>2496</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>125</td>
<td>12</td>
<td>1500</td>
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### Study sites

**Transport**

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<tr>
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<tr>
<td><strong>Total</strong></td>
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**Transect Walk in Sinkata**
Transect walk in Gira Aras

Transect walk in Megab
List of interviews and participants

<table>
<thead>
<tr>
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<th>Number of Participants</th>
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<tbody>
<tr>
<td>1 (Sinkata)</td>
<td>8</td>
<td>5/3</td>
</tr>
<tr>
<td>4 (Gira Aras)</td>
<td>8</td>
<td>5/3</td>
</tr>
<tr>
<td>7 (Megab)</td>
<td>7</td>
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<tr>
<td>10 (Gule)</td>
<td>6</td>
<td>3/3</td>
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<td><strong>Total</strong></td>
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<td><strong>16/13</strong></td>
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Case studies

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<th>Gender</th>
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Transect walk in Gule
<p>| | | | |</p>
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<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Sinkata</td>
<td>A.</td>
<td>Farmer</td>
<td>Female</td>
</tr>
<tr>
<td>Sinkata</td>
<td>T.</td>
<td>Farmer</td>
<td>Female</td>
</tr>
<tr>
<td>Gira Aras</td>
<td>H.</td>
<td>Farmer</td>
<td>Male</td>
</tr>
<tr>
<td>Gira Aras</td>
<td>B.</td>
<td>Farmer</td>
<td>Female</td>
</tr>
<tr>
<td>Megab</td>
<td>M.</td>
<td>Farmer</td>
<td>Male</td>
</tr>
<tr>
<td>Megab</td>
<td>A.</td>
<td>Farmer</td>
<td>Female</td>
</tr>
<tr>
<td>Megab</td>
<td>G.</td>
<td>Farmer</td>
<td>Male</td>
</tr>
<tr>
<td>Gule</td>
<td>S</td>
<td>Farmer</td>
<td>Male</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Interviewee</th>
<th></th>
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<td>Farmer</td>
<td>Male</td>
</tr>
<tr>
<td>Gule</td>
<td>H., Tabea Chairman (Gule Kebele Leader)</td>
<td>Farmer</td>
<td>Male</td>
</tr>
<tr>
<td>Gule</td>
<td>DH (DA1)</td>
<td>Farmer</td>
<td>Male</td>
</tr>
<tr>
<td>Gule</td>
<td>DA2</td>
<td>Development Agent</td>
<td>Male</td>
</tr>
<tr>
<td>Wukro</td>
<td>F.T.</td>
<td>Irrigation engineer, Water Resources Office</td>
<td>Male</td>
</tr>
<tr>
<td>Wukro</td>
<td>T.</td>
<td>irrigation expert, Agriculture and Rural Development (ARD) Office</td>
<td>Male</td>
</tr>
<tr>
<td>Wukro</td>
<td>G.</td>
<td>Food Security expert, ARD Office</td>
<td>Male</td>
</tr>
<tr>
<td>Wukro</td>
<td>W.</td>
<td>rural road construction and transport office</td>
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REFERENCEs


Burgess, Robin, et al. (2010), 'Our Turn To Eat: The Political Economy of Roads in Kenya'.


Devereux, Stephen (2009), 'Seasonality and social protection in Africa'.


Dokken, Therere (2013), 'Land tenure in Tigray: How large is the gender bias?', (Centre for Land Tenure Studies, Norwegian University of Life Sciences).


Fouracre, Phil (2001), 'Transport and Sustainable Livelihoods', (Transport Research Laboratory).


Gebreselassie, Samuel (2006), 'Land, Land Policy and Smallholder Agriculture in Ethiopia: Options and Scenarios'.


Haile, Mitiku, et al. (2005), 'Research Report 2 Land Registration in Tigray, Northern Ethiopia', *IED, Mekelle University and Central Research Department, DFID*. 


LOMBARD, P and COETZER, L (Year unknown), 'THE ESTIMATION OF THE IMPACT OF RURAL ROAD INVESTMENTS ON SOCIO-ECONOMIC DEVELOPMENT'.


Munro, R. Neil, et al. (2008), 'Soil landscapes, land cover change and erosion features of the Central Plateau region of Tigrai, Ethiopia: Photo-monitoring with an interval of 30-47 years', *CATENA*, 75 (1), 55-64.


Porter, Gina (2003), 'Spatio-Temporal Perspectives on the Social Benefits and Costs of Roads and Road Transport: A Discussion Paper with Special Reference to
Women and Children', *TRL Workshop on Framework for the inclusion of social benefits in transport planning* (Bracknell, UK: Transport Research Laboratory).


TRL (1997), 'Principles of Low Cost Engineering in Mountainous Regions, with Special Reference to the Nepal Himalaya', *Overseas Road Note* (Crowthorne/London: TRL/Overseas Development Administration).


WSDP (2002), 'Water Sector Development Programme 2002-2016', in Ministry of water resources (ed.).