



Tracing the Causal Loops Through Local Perceptions of Rural Road Impacts in Ethiopia

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Summary. — To better grasp the interconnected range of socioeconomic impacts from the implementation of rural roads in northern Ethiopia, we have experimented with Causal Loop Diagrams (CLDs), a tool commonly used in systems dynamics, but generally under-used in development research. The expansion of the rural road network in Africa is praised for reducing spatial isolation, lowering transport cost, increasing access to markets, and bringing services closer to home. However, different segments of society will benefit differently from the establishment of a rural road. This difference may lead to dynamics that either exacerbate or reduce existing inequities, which forms the central question for this paper. As part of a broader study on the multiple (in)direct effects of rural roads on productive employment, we undertook oral testimonies in four municipalities to explore how people perceive road impacts on livelihoods, mobility, and work. CLDs were then used to assemble those seemingly loose observations into a systematized view of the whole. The exercise reveals conflicting feedback processes that may dominate system at different times and drive the inequities between surplus food producers and laborer households up or down. The method used can be particularly useful for studying similar infrastructures that seemingly bring benefits to all, but may cause subtle, concealed or delayed effects, and ultimately surprising system behavior.
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1. INTRODUCTION

Development policy generally starts by investigating how effects follow causes in the hopes to confront root problems rather than symptoms. In spite of the efforts, poverty and inequity persist partly because of the failure to unravel how effects can also affect causes. Systems can indeed be understood as interconnecting feedback loops where cause and effect chains circle back upon themselves. The principle of diminishing returns, for example, represents a balancing feedback loop with a stabilizing effect on the economy. Systems thinkers have commented that economic models tend to overestimate such balancing mechanisms at the expense of reinforcing feedback loops that might push existing growth and decline patterns away from equilibrium (Arthur, 1999; Bowles, Durlauf, & Hoff, 2006; Meadows & Wright, 2008; Saeed, 2011; Whelan & Msefer, 1996). Dissenting voices from within the discipline of economics also recognize that neoclassical models cannot generate instability (Minsky, 1982 in Keen, 2011). “The dynamic, non-equilibrium social system that is a market economy should be analysed with dynamic, non-equilibrium tools” (Keen, 2011: p. 33).

A promising toolset is provided by the field of system dynamics. Its main technique for tracing cause and effect chains is the Causal Loop Diagram (CLD). The diagrams uncover multiple and conflicting processes of feedback and can therefore help clarify less visible and slower changes in a system. The technique has been developed and applied by Forrester (1968), Meadows, Meadows, Randers, and Behrens (1972), Sterman (2000) and many others in the fields of management, population, industrial and ecological dynamics. It remains a little known tool in development studies despite its potential to complement the descriptive methods commonly used in field research. We illustrate its applicability in the context of the substantial investments in rural roads that took place in Ethiopia in the last couple of decades (Emmenegger, 2012; ERA, 2013).

The disastrous social and ecological disruptions from costly white elephants, such as large hydroelectric dams or nuclear power plants, have long captured the critical eye of development scholars (Robinson & Torvik, 2005). The causal links are quite obvious, especially in hindsight. By contrast, other infrastructures may bring benefits to all, but their distributional effects are subtler, concealed, and delayed. This could lead to “hidden” dynamics that may worsen rather than reduce social inequities. This may indeed be the case for rural roads in Tigray, one of nine regional states in Ethiopia. On the surface, their construction inspires euphoric reactions. Quoting interview respondents: “the road is our bloodline”, “roads lead to heaven”, “the road is development”, “the road is life” (M/66, 19-02-15, Adi Kisandid; F/40, 27-02-15, Hade Alga; M/24, 24-02-15, May Quiha).¹ Beyond these initial praises, however, interviews revealed a wide range of statements about the (in)direct effects of rural roads on development. For example, only farmers with sufficiently high levels of output might be able to afford and benefit from bulk transportation services. A new road could therefore increase their competitive advantage over marginal farmers. Respondents often focused on a specific causality, which would then be complemented or contradicted by other respondents. Going beyond individual statements, the interview data as a whole can be brought together with the use of CLDs to provide a rich and complex picture of economic life and of the function of rural roads.

Approaching the matter in this way is new in a long history of road research. Studies in human and development geography have already suggested that road impacts are distinctly

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distributed among a local population and that this would have long-term adverse effects on distribution (DeGrassi, 2005; Emmenegger, 2012; Gallé, 1989), but those expectations have generally remained unqualified and unquantified. In contrast, economic models in infrastructure impact studies generally endorse road investments by forecasting that these will reduce transaction costs, market volatilities, poverty, and spatial inequalities (see for example Arethun & Bhatta, 2012; Dercon, Gilligan, Hoddinott, & Woldehanna, 2009; Terefe, 2012). In reality, there are several causes for concern. Markets in Tigray show frequent successions of improvements and deteriorations in the local terms of trade (World Food Program, 2016). Every now and then price fluctuations even become volatile (Hadley *et al.*, 2011). At the same time, there is persistent poverty, inequity and malnutrition (Ferede & Kebede, 2015; Hadley *et al.*, 2011; Rajkumar, Gaukler, & Tilahun, 2011). The situation could of course have been worse in the absence of Ethiopia's road investments, but this is hard to establish based on economic models that tend to be primed to generate stability. They also fail to tell us the causes for a particular behavior and therefore how that behavior might possibly change in the future (Meadows & Wright, 2008).

This leads to the following questions: what are the potential and observed economic impacts from rural road infrastructure on different social groups? What does the distribution of those impacts mean for the long-term alleviation or aggravation of existing inequities? CLDs are intended to help understand the nature of these questions by identifying the feedback mechanisms at play. In future work, these could be explored quantitatively, for example through formal dynamic models. We will revert to this in the conclusions.

The focus of the article is on road and transportation infrastructure and its impacts on productivity and employment, even though other dimensions of development such as welfare, culture, health and education might be affected as well. Development is therefore distinguished from economic growth and the article focuses particularly on the qualitative dimension of equity, which is defined as justice and fairness in the distribution of assets and benefits. After a methodological clarification, the results are presented in two distinct sections: the first deals with the local perceptions of the infrastructure's impacts on rural life; the second with the distribution of these impacts.

2. METHODS

This paper compiles findings from a first step in a larger study² on the (in)direct effects of rural roads on productivity and employment in Tigray regional state in northern Ethiopia.

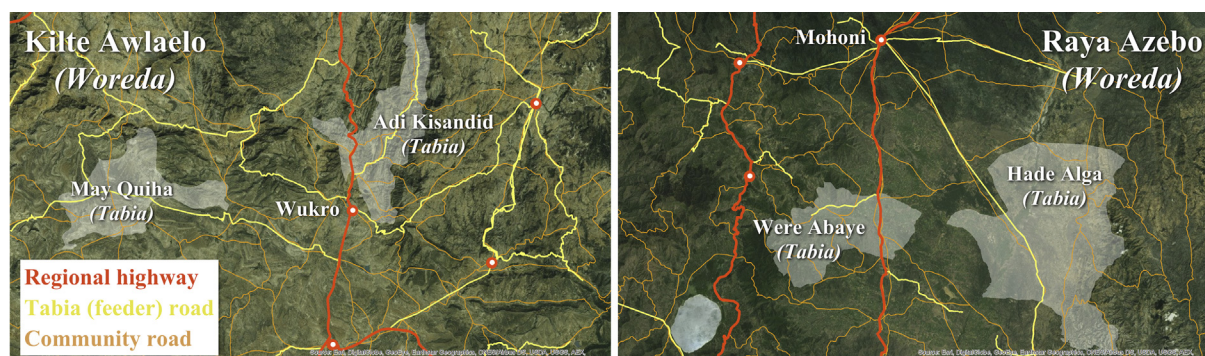
The aim of this step was to assess how people experience and represent rural road developments in their direct surroundings. The study sites are in Kilde Awlaelo and Raya Azebo, two of Tigray's 35 *woreda* or districts (see Map 1). The *woreda* centers are Wukro and Mohoni, respectively. Distances from the centers to the study sites varies from about 6 to 40 km. Kilde Awlaelo is situated at higher altitude, features mountainous terrain and is generally intensively irrigated and developed for commercial cropping. Raya Azebo is lower, more arid and includes pastoralist activities. Two *tabias* (rural communities)³ were selected in each *woreda*. A *tabia* might in turn contain four to six villages called *kushet*. It includes a center for its local administrative headquarters, sometimes with a market place or a school.

The study excludes federal highways between the regions and regional highways between *woreda* headquarters. Two types of rural roads connect *woreda*, *tabia*, and *kushet* (based on Emmenegger, 2012; ERA, 2013):

1. *Feeder roads*: These are mostly dry-weather unpaved gravel roads⁴. They serve as traffic feeders from *tabia* centers and facilities of socio economic importance to *woreda* centers or to the nearest all-weather road⁵.
2. *Community roads*: These include the dirt paths and tracks between *tabia* centers, between *kushets* and *tabia* centers as well as between *kushets*.

A government target has been to establish a feeder road in every *tabia*. The age of a road is an important variable when studying short- and long-term impacts. The selection therefore included two feeder roads implemented recently in Adi Kisan did and Were Abaye (2010–15) and two older feeder roads, for which construction began in the late 1990s in May Quiha and Hade Alga.

A useful data collection technique to learn about a particular event, such as a conflict, a flood or the establishment of a road, is the oral testimony (Herbert & Rodger, 2007; Slim, Thompson, Bennett, & Cross, 1998). The testimonies involved face-to-face in-depth and unstructured interviews. The checklist included general questions about the respondent, his or her occupation, mobility, and household composition. Other open format questions were directed toward the anticipated and observed effects of the feeder road in terms of costs/benefits or advantages/disadvantages. To enhance the diversity of responses and minimize possible biases, our sampling was accidental (not random). The variables were: time of the interview (various hours of the day), market and non-market days, different *kushets*, different distances from the road, and different gender and age groups. Out of 40 respondents (~10 per *tabia*), 16 were female and 24 were male. Women are relatively constrained in their mobility and were therefore



Map 1. Study sites (*tabia* boundaries in gray).

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