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# DEFICIENCY OF INTEGRATION AMONG THE DOMAIN INFRASTRUCTURE SECTORS AND THE RESULTING SOCIO-ECONOMIC COSTS

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## ABSTRACT

*Infrastructure is by far very indispensible and fundamental for any socio economic development of a nation or of any local economy. By their nature, they are strongly interdependent with each other. Thus, the construction of one sector or part of it has an adverse effect up on the other sectors. The aim of this study is to examine the deficiency in the integration of infrastructure sectors and the resulting socio-economic costs in case of Dessie town. To conduct the study, four domain sectors are to be selected namely, telecommunication, road/transport, water and power sectors. With the use of both primary and secondary sources of data from the workers of the above sectors and from the residents of the town, the analysis has been made. The study revealed the fact that integration among the four domain sectors is almost none. The real cost incurred on the specific common corridor is 93.66 times the optimal amount for the unasphalted common corridor and 167.07 times higher for the asphalted common corridor if maintenance is to be made in the absence of integration among the sectors. The social cost of the deficiency in integration has been studied via the willingness to pay of the community for the interrupted DISs. More than half of the respondents responded as if they are wilful to pay more than four times the prevailed price of the infrastructure service during its normal functioning times. This implies the prolonged service interruption due to delay in maintenance of a particular sector (hurt by another sector) has created serious discontentment of the community. Thus, without alternative, it is the integration among the DISs that can shorten the maintenance period of Infrastructure assets at the common corridor.*

*Thus, information sharing about their plans, accidental wound reports about the common corridor's infrastructure component would enable each sector to respond immediately to shorten the period which in turn lessons the cost of maintenance and the social discontentment of the community.*

## PROBLEM JUSTIFICATION

Infrastructures are a complex web of public and private assets, created and operated with in Layers of the government that have varying jurisdiction over their locations, design and pricing, accessibility and general operation. How can anyone coherently address such real world complexity? (Christopher et.al, 2006) Good infrastructure design and operation is not solely a technical issue. The interface between technical and social considerations is poorly understood and inadequately managed at the level of overall systems. Despite the importance of infrastructure, there is compressive theory for it; there is no best practice approach for its design, management and transformation. We lack rigorous methods for developing, evaluating and evolving future infrastructure architectures that must incorporate legacy elements while also responding to new technologies, knowledge and demands. The fact is the traditional academic discipline neither motivate nor support this kind of multi-domain, multi disciplinary approach.

The economy hosts various and serious infrastructure challenges. Demand for such services rapidly bypasses the supply of the services resulting in a decreased performance and reliability Socio-economic cost of the economy will be high of the productive sectors. (Patrica A, Dalton, 2008). Despite the rapid increment of the effective demand for infrastructure services, the capacity of investing and managing infrastructure of the government is too low. Most of these infrastructures, elsewhere in the world, are owned and operated by either the state or the local governments. For instance, almost 99% of the road and bridge infrastructures are owned and operated by the state government while more than 80.5 % of the land transportation services are owned and operated by the private sectors (Transformation plan, 2003). As most of the physical infrastructures are owned and operated by the public agencies, lots of inefficiencies are recorded in the provision and expansion sessions of infrastructure assets and services. The coordination existed between different sectors is nill.

Thus, this investigation is intended to examine the type of oversight made and extents of losses recorded in these service providing sectors due to lack of integration among themselves.

## OBJECTIVES OF THE STUDY

The general objective of the study is to cross examine the integration of various infrastructure service providing agents through their plans and implementations. The corresponding specific objectives of the study are:

- To identify the economic, physical and functional characteristics of each domain of infrastructure
- To examine the level and type of integration between each domain of infrastructure sectors
- To analyze the quantitative spillover costs resulted by one sector on the other
- To explore the dissatisfaction /qualitative costs of the community due to lack of integration

## HYPOTHESIS OF THE STUDY

For the achievement of the aforementioned objectives and problems, the following propositions have been hypothesized:

- The rehabilitation, advancement and development of one infrastructure sector affect adversely the functioning as well as the health of the other infrastructure sector.
- The integration or coordination between domain infrastructure sectors is weak.
- Significant socio-economic losses have been there due to deficiency in integration among.

## RESEARCH METHODOLOGY

The research methodology encompasses both of analytical and descriptive research types. Having considered the existence of quantitative and qualitative data and time series information of all sectors expected to the study, the use of both techniques will be off important. The whole designs of the research hold the following path.

### Data Sources and Types

The common data sources, primary and secondary, will be utilized in the way to investigate the real impact of one sector enhancement, either in quantity or quality, on the other. The first hand information is planned to be gathered from the people of the town lived for at least three years and from the higher officials of the aforementioned infrastructure sectors. Regarding the secondary sources of information, critical examination of the existing literatures related to Infrastructure will be the main base.

### Techniques of Data Collection

The relevant information required for the study will be collected from primary and secondary sources in which both of them will be collected through the following instruments:

**In-depth interview**: Individual in-depth interview of about 3 randomly selected officials of each sector is to be done to ascertain the impact of one sector expansion and rehabilitation on the other sectors.

**Field studies**: Field visits is to be done to gather first hand information on various types of infrastructure sectors (pro, neutral and against) on other sectors.

**Questionnaire**: Structured questionnaire will be one of the instruments utilized for the collection of relevant first hand information from the permanent residents of the town who are users of the services provided from the sectors under question. One type of questionnaire will be prepared and distributed for the 120 randomly selected clients of the sectors" services to ascertain the impact of one sector expansion and rehabilitation on the other sectors and eventually on their environment.

**Observation**: The investigator personal observation of the integration levels and types among the sectors will serve as one of the tools to underpin the real information acquisition about the investigation.

## Sampling Technique and Sample size Determination

### Sample Size Determination:

Here, Pagoso sample size Determination formula has been used to determine the sample size of the study. It is shortly disclosed as: $n = \frac{N}{1+Ne2}$ , where

n= is the size of the sample

N= the size of the population

e= the margin of error.

The total population of the town is estimated at 120,095 (CSA, 1999). Of this, assuming that 30,000 would be economically active to observe and to be affected directly and greatly by the Infrastructure sectors' development and redevelopment. Having this as a target population, n= 394.73 395.Even though, the above formula enables us to determine the total sample size, proportional sampling approach has been used for selecting sample elements from each urban kebeles of the town. That is, SP= 39.5 .

### Sampling Technique

Inclusion of all the elements of the population in the study is impossible and if possible it demands huge costs of time and material. Thus, for the sake of efficiency, sampling is indispensible. The study under consideration is going to use both random and non random sampling techniques. Among the non random sampling technique purposive will be utilized so as to select officials of each infrastructure sectors for in depth interview. From random sampling techniques simple random sampling will be used to select respondents from the kebeles.

## Data Analysis and Interpretation

The gathered information is going to be decoded and categorized based on some common features of the variables using the computer program called MS EXCEL. Then, it will be analyzed with the help of soft wares like SPSS and STATA. In fact, these soft ware's require statistical tools such as measures of central tendency and measures of depression variables. Hence, in accordance of the values of the variables, the interpretation will be made.

## LITERATURE REVIEW

## Concepts and Types of infrastructure and its Interdependencies

Conventionally, interdependencies have been considered to be either physical or geographic. An example of a physical interdependence is that the water supply infrastructure depends on electric power to operate its pumps while, at the same time, the electric power infrastructure must have water to make steam and cool its equipment. Geographic interdependencies arise when infrastructure components, e.g., water and waste water pipelines, power transmission lines, gas pipelines, telecommunication cables and road share common corridors thus increasing the vulnerabilities to and consequences from local hazards or sabotage. ( Peeren boom, 2001)

However, later on cyber and logical interdependencies of infrastructure sectors have been identified. Therefore, four basic categories of interdependencies are described here:

*Physical*, where the output of one infrastructure is used by another;

*Cyber*, where an infrastructure depends on information transmitted through the information and communications infrastructure; banks, insurances wiz tele.

*Geographic*, where two or more infrastructures are co-located, such as in a common utility corridor, and can be affected by a local event; and

*Logical*, where the state of an infrastructure depends on the state of another Infrastructure in a way that is not physical, cyber, or geographic (e.g., inkages through financial markets)

In addition to the four types of interdependencies mentioned above, the degree to which infrastructures are linked also influences their vulnerabilities and response requirements. Some linkages are loose and thus relatively flexible, such as the linkage between a water treatment facility that maintains a large inventory of chlorine and the transportation infrastructure that delivers the chlorine. Short-term disruptions of the transportation system may not affect water treatment. Other linkages are tight, leaving little or no flexibility for the system to respond to changing conditions. For example, electric powered pumps would be immediately affected by a loss of electric power. Such linkages vary in scale and complexity and must be appropriately considered in analyzing infrastructure vulnerabilities and response actions.

### Dimensions of Infrastructure Interdependence

Several major dimensions for describing infrastructure interdependencies have been identified. These dimensions are briefly discussed below. Three types of failures can affect interdependent infrastructures.

A cascading failure: is a disruption in which one infrastructure causes a disruption in a second.

An escalating failure: is a disruption in one infrastructure that exacerbates an Independent disruption of a second infrastructure (e.g., the time For restoration of a failure of water pipeline increases because The transportation infrastructure has a failure that prevents parts or repair workers from reaching the failed pipeline).

A common cause failure: is a disruption of two or more infrastructures at the same time as the result of a common cause (e.g.by hazard).

### Costs of Infrastructure Interdependence

One of the major costs posed by interdependency is the time required to restore service to key infrastructure components that have been lost or degraded. Such losses adversely affect the deliverability of a commodity and/or the performance of other infrastructures that depend on that component for their respective operations.

### Economic Costs Of Infrastructure Dyfunctioning

Risk in the 21st century results from a complex mix of manmade and naturally occurring threats and hazards, including terrorist attacks, accidents, natural disasters, and other emergencies. Within this context, our domain infrastructure (DI) may be directly exposed to the event themselves or indirectly exposed as a result of the dependencies and interdependencies among DI. Within the DI protection mission area, national priorities must include preventing catastrophic loss of life and managing cascading, disruptive impact economy across multiple threat scenarios. Achieving this goal requires a strategy that appropriately balances resiliency with focused, risk-informed prevention, protection, and preparedness activities so that we can manage and reduce the most serious risks that we face.

## DISCUSSION AND ANALYSIS

### Introduction

The analysis of the study has been relied on the data gathered from one thirty respondents. Of which twenty four were employees from domain infrastructures who are technicians while the rest were from the common people of the town as community members.

### Types and Levels of Integration among the Domain Infrastructure Sectors

Here under, the existence of integration among the DIS by their nature, the type and level of integration among them were discussed. With regard to the types of integration, literature put forwards four commonly known forms of integration.

Cyber form of integration whereby sectors carryout their regular activity with the transfer of information for example, financial institutions uses telecom and internet for the activities and others also: physical integration if the output of one sector is used as an input by the other sector. Geographical integration is the one where the sectors share the common corridor that is a common plot at which two or more infrastructure type of assets is existed.

Almost all (22) of the respondents who were employees of the domain infrastructure sectors recognized the fact that there exists natural integration among the four domain infrastructure sectors. Furthermore, they were able to identify the type of integration existed among these sectors: viz-a-viz cyber, geographic, logical and physical integrations in one or in combined forms. The geographic type of integration surpasses the rest implying that a specific plot, one may get a minimum of two or four of the infrastructure sectors; followed by cyber and physical integration types.

Unlikely to the above fact, when we proceed to the examination of the real sectoral interdependence *of the DIS,* The responses from the technicians of the DIS revealed that the real integration, despite the strong intertwistness of the DISs, has been almost none. Hence, unless the actual integration is consistent with the natural ones, costs would be by far more than the anticipated. The complexity of dealing with several different infrastructures at once may be an important cost factor. Road construction works for example increasingly have to cross or handle other surface transport modes as well as pipelines for district heating, electricity cables and drainage systems.

Indeed, the cost of managing such interaction with other types of infrastructures may well prove increasingly burdensome in the future, unless appropriate solutions can be found (for instance, the application of GIS).

### Impaired components of DISs and their causes

Development or destruction in one infrastructure sector can have important implications for development or destruction in another. The reconstruction for one might be the destruction for the other especially if they shared the corridor commonly. Both the community at large and the technicians have been asked whether impaired component of DISs in the last three years encountered or not. Table 4.6 depicted that 106 of the community respondents out of 130 replied as there were impaired parts of DISs while 23 out of 24 technicians approved the occurrence of wounded DISs in the last three years.

The intention is to determine the major causes for the impaired component to be wounded. Accordingly, nearly one third of the community and half of the technicians responded that causes were either one or more of the other sectors. Hazards, unknown factors (obsolesce) and individuals were also mentioned as the causes for the ruin of the infrastructure components with their respective intense of influence. The responses of the technicians have been distinctly illustrated from those of the community for the fact that the former could better disclose the causes professionally than the later. Indeed, not few respondents from the community, 24 in number have responded as they didn’t have encountered destructed components of DISs.

The plummeting of an electricity rod tears down the pole of telegraph and the other way round. In this context, even though the cause for the first is attributed to hazard, it’s the other sector for the telecommunication component disruption. Hence, sectors might disturb. The other sectors health with either exogenous or endogenous forces. Where as individuals, for their selfish use, might destruct a part or parts of an infrastructure component.

The line of interaction could also be watched from the information sharing aspect regarding such fallen down rods and other dysfunctional components of DISs. It’s the affected community who mostly provides the information to the sector whose asset is impaired. In fact, it would be expected from the given sector that destructed the others’ asset need to inform the mother sector, had there been recognition of their actual interdependence. It’s 74% of the informants were the community, not ht e destructing sector. The later constitutes only 8%, very negligible. This unidirectional information didn’t get trust to have immediate response coupled with the less preparedness and zero resilience strategy of the sectors as there was no pre information about that. The worst is that prudently secured investment, development or maintenance couldn’t be made at that corner because the technician of the given sector might not know anything about the proper fitness of the other sectors asset at that corner exposing it for immediate digging by the other sector.

### Act of Maintenance

The complexity of dealing with several different infrastructures at once may be an important cost factor. Road construction works for example increasingly have to cross or handle other surface transport modes as well as pipelines for district heating, natural gas supplies, electricity cables and drainage systems.

Indeed, the cost of managing such interaction with other types of infrastructure may well prove increasingly burdensome in the future, unless appropriate solutions can be found (*e.g.* the application of GIS technologies).

As the above table disclosed the fact practiced by the domain infrastructure sectors, most of the maintenance activity is made by the sector which created the disturbance alone. Especially in telecommunication sector, all the maintenance of the wounded component is made by itself though it is a common corridor. In other words, the sector which made the disturbance or observes the impairment first undertakes the maintenance without informing other sectors those have shares in the corridor. Hence, the other sector will come back and rebuilt that preceding repaired corridor due to improper or null maintenance. Joint act to maintain components at the common corridor is zero so that one sector after the other comes to dig and re-dig the same impaired part consisting area. This has heavy implication on the cost of infrastructure at large and on the maintenance cost of infrastructure in particular.

## Infrastructure Costs

A large share of the infrastructure expenditures is related to the creation, renewal and maintenance of infrastructure assets with an expected lifetime of more than 1 year. This means that the expenditures made in year X do not equal to the infrastructure cost for year X, the yearly value for the use of the infrastructure assets.

The poor real integration among the sectors resulted in high irreversible costs which are of different in their type and nature**.** We are living and doing in the world of having general resource scarcity particularly in a country where the capital inputs are extremely low.

### Sunk cost of Infrastructure

In the recurring cost of maintaining the small plot or the big part of infrastructure asset, sunk cost covers the larger part. Furthermore, as we all know most of the raw materials used to construct infrastructure assets are tradable by their nature either tradable exportable or tradable importable. Thus, the cost remained as sunk in the construction and reconstruction of assets has multiple adverse effects.

### Estimated Sunk Cost of maintenance

A "sunk cost" is a cost that one has already been incurred and that one cannot recover. A sunk cost differs from other, future costs that a business may face, such as inventory costs or R&D expenses, because it has already happened. Sunk costs are independent of any event that may occur in the future. The sunk cost varies from investment to investment, it’s higher for infrastructure investments.

Be it maintenance or new development. This particular cost is different plot types. For the unasphalted Area, the digging out cost (maintenance sunk cost ) is lower than the asphalted area.The estimated sunk cost raises by 93.66 birr per unit of maintenance sit increment at soiled common corridor. The constant value can interpreted as the average amount of maintenance cost needed to maintain a single site in the absence of the other sectors.

### Case of Asphalted common corridor

Here the estimated sunk cost incurred and to be incurred is by far greater than the one mentioned above. The intercept amount is more than 3 times the soiled common corridor for the same site size.

The rate of increment in the sunk cost for asphalted common corridor is nearly twofold than the soiled common corridor. For a unit increase in the maintainable site, the sunk cost of maintenance increases by 167.07unit. If the common corridor dug out by different sectors one after the other due to absence of integration, the sunk cost is going to be duplicated by the amount of rate of increment.

### Willingness to pay as cost proxy of social cost of interrupted Infrastructure service

Service interruptions can occur due to unexpected emergencies or system failures, as well as for planned maintenance. The expected frequency, timing, and duration of interruptions can be affected by the capital investments and operations of the supplier, with higher levels of service generally being attainable through higher costs and hence higher prices. To determine the appropriate level of this service attributes relative to price, information is needed on the value that customers place on each attribute. Thus, if the willingness to pay of the society is higher for the infrastructure services which that is instantly interrupted, we can deduce the fact that the social cost of maintenance is higher. If the service outage of the other sector's service extended, the social cost (discontentment) of the community duplicates.

Table 3.9 illustrated the fact that discontentment of the family, health problem (sanitation and Communicable diseases), delay to and from work place, less competitiveness are the common problems which the affected community is suffering from. Nearly, 88.3% of them witnessed this. The extent of thehurt depicted with their willingness to pay where 52.42% of the affected community wills to pay 4times or more for having the smooth service of the interrupted infrastructure.95.14% of them has shown their willingness to pay of 2 times or more. Hence, the intangible cost of service interruption due to the mainte-nance and development of the other infrastructure service is high that needs the integral act of the different infrastructure service operators thereby to shorten the time of interruption or repeated interruption.

### CONCLUSION

Infrastructure sectors are the most interdependent sectors for they are using common surface or under surface corridors. Hence, the healing of one may cause the killing of the other on that same corridor if there is no strong integration among the various sectors 'operators. Three types of failures can affect interdependent infrastructures. A cascading failure: is a disruption in which one infrastructure causes a disruption in a second. An escalating failure: is a disruption in one infrastructure that exacerbates an Independent disruption of a second Infrastructure (e.g., the time for restoration of a failure of water pipeline increases because the transportation infrastructure has a failure that prevents parts or repair workers from reaching the failed pipeline). A common cause failure: is a disruption of two or more infrastructures at the same time as the result of a common cause (e.g.by hazard).

In the examination of the real sectoral interdependence *of the DIS,* the responses from the technicians of the DIS revealed that the real integration, despite the strong intertwistness of the DISs, has been almost none. Hence, unless the actual integration is consistent with the natural ones, costs would be by far more than the anticipated. The complexity of dealing with several different infrastructures at once may be an important cost factor. Road construction works for example increasingly have to cross or handle other surface transport modes as well as pipelines for district heating, electricity cables and drainage systems.

With regard to the spillover costs, as the integration among the domain infrastructure sectors nullifies, the spillover cost rises. Even, excluding the spare parts cost (ruin), the dugout cost raises by 93.66 and 167.07 units for unasphalted and asphalted common corridors.

The discontentment of the community fallen under regular service interruptions is taken as a proxy for the social cost of lack of integration can occur due to unexpected emergencies or system failures, as well as for planned maintenance. The expected frequency, timing, and duration of interruptions can be affected by the capital investments and operations of the supplier, with higher levels of service generally being attainable through higher costs and hence higher prices. To determine the appropriate level of these services attributes relative to price, information is needed on the value that customers place on each attribute. Thus, if the willingness to pay of the society is higher for the infrastructure services which that is instantly interrupted, we can deduce the fact that the social cost of maintenance is higher. If the service outage of the other sector's service extended, the social cost (discontentment) of the community duplicates.

The study illustrated the fact that discontentment of the family, health problem (sanitation and communicable diseases), and delay to and from work place, less competitiveness are the common problems which the affected community is suffering from. Nearly, 88.3% of them witnessed this. The extent of the hurt depicted with their willingness to pay where 52.42% of the affected community wills to pay 4times or more for having the smooth service of the interrupted infrastructure.95.14% of them has shown their willingness to pay of 2 times or more. Hence, the intangible cost of service interruption due to the maintenance and development of the other infrastructure service is high that needs the integral act of the different infrastructure service operators thereby to shorten the time of interruption or repeated interruption.

## RECOMMENDATION

Recognizing the strong interdependence among the infrastructure sectors by their nature, each sector operators need to back it up by their plan and implementation activities. Information sharing among each sectors about the common corridor planned maintenance activities was zero in the previous periods. This has ended up in duplication of social and economic costs on the town economy. Thus, the researcher suggests them to establish a sectoral council that organizes the strategic plans, annual plans and other accidental wound reports of each sector in the town boundary so that combined act of each sector operators can be there.

Unity creates synergy –principle can serve the sectors to shorten the interruption period and or the reconstruction of the common corridor by different sectors in the same year. This in turn enables the sectors to minimize the social cost of the society revealed by their willingness to pay for the interrupted service maintenance. All in all sectoral integration particularly DISs saves important scarce resources via the minimization of costs of development and maintenance of infrastructure components at the common corridor.

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