CHAPTER III

INFRASTRUCTURE DEVELOPMENT

3.1 Defining Infrastructure

Infrastructure is an extremely wide-ranging notion which can be linked to every facet of the economy and human life. Over the past century, as man-kind has advanced both technologically and socially, transport, telecommunications, energy and water networks have become part and parcel of human existence, occupying central roles within both household life and economic production. In fact it is difficult to imagine a modern world without such conveniences. Accordingly, a lack of such infrastructure facilities is considered to be a major structural weakness that can hold back economic growth and development, while the lack of access to such facilities is generally a key dimension in any definition of poverty (UNESCAP, 2006). Because infrastructure is such a multi-dimensional topic, its list of associated issues is lengthy. For any useful analysis of infrastructure-related issues to lead to a progress-oriented discussion, it is necessary to narrow down the definition of infrastructure and its associated issues.

As previously stated, an essential requirement for economic growth and sustainable development is the provision of efficient, dependable and generally inexpensive infrastructure services. But what exactly is infrastructure? According to UNESCAP (2006), the term infrastructure has been used since 1927 to refer collectively to the roads, bridges, rail lines and similar public works required for an industrial economy to operate. Yet the term did not become commonly utilized until the Second World War when military strategists adopted it to use in reference to the wide-ranging elements of war logistics (Ahmed & Donovan, 2002). In the years following, economists introduced the term into the literature of development economics to be used interchangeably with what had previously been known as 'overhead capital.' Since its incorporation into the economics lexicon, infrastructure has become an extremely popular word,

often being used extremely loosely, yet it has almost completely replaced overhead capital inmost common vernacular (Youngson, 1967). Before long, distinctions such as 'social infrastructure,' 'economic infrastructure,' 'physical infrastructure,' and 'institutional infrastructure' emerged in order to emphasize a particular dimension of the many characteristics that have since been attached to the term infrastructure (Ahmed & Donovan, 2002: 2).

Transport	**Energy**	**Telecommunications**	**Water**
Road Networks	Generation System	Distribution Networks	Water Storage
Bridges	Distribution Networks	-National	Irrigation
Rail Networks	-National	-Regional	Flood Protection
Sea Ports	-Regional	-Local	Water treatment
Air Ports	-Local	Switches/Exchanges	Distribution Networks
Transport Support: Lighting, Signals, Etc.	Storage Transformers	Telephone Equipment	Wastewater Treatment
			Sewerage Systems

Table 3.1: Categories of Physical (Hard) Infrastructure (NZMED, 2005)

Infrastructure can loosely be defined as the physical structure of facilities through which goods and services are provided to the public. The 1950s and the 1960s witnessed a surge of attempts in development economics to further specify the contents 'overhead capital,' or infrastructure, a term that at that point was rapidly gaining preference among economists (Ahmed & Donovan, 2002). Significant expansion of the concept ensued. Lewis (1955) made the first addition in 1955, including public utilities, ports, water supplies, and electricity in the specification of infrastructure, this rounded out the definition of what is generally known today as 'hard infrastructure.' In 1958 Albert Hirschman (1958) incorporated elements of 'soft' infrastructure, such as law and order, education, public health, transportation, communications, power, water supply, irrigation, and drainage. And Benjamin Higgins (1959) included transport,

public utilities, schools, and hospitals to the definition of infrastructure. Furthermore, reflecting a heightened recognition of the role of agriculture in economic development, the literature of the 1960s reflects an added emphasis on agricultural research and extension, rural financial institutions, and irrigation and drainage as extensions of infrastructure.

Because of several characteristics of infrastructure, including its wide range of externalities and a long gestation period, Governments are primarily responsible for the institutional arrangements necessary for the provision of infrastructure facilities. Through a mixture of state-run construction firms, publicly owned utilities providers and governmental regulatory agencies, infrastructural services are planned, created, maintained, and distributed with mixed success. Funding for these projects comes mainly from two sources, public funds, generated through taxes, as well as official lending and donor agencies like the World Bank, the Asian Development Bank, etc. Public expenditure on infrastructure, despite being the standard throughout much of the world, raises several important macro-economic questions. For example, how much public expenditure on infrastructure is too much? A dilemma which if not balanced, could lead to fiscal instability, a serious problem in countries that are trying to attract foreign investment (ADB, *et al.*, 2005). On the flip-side however, too little public expenditure runs the risk of endangering economic growth and poverty reduction efforts. The Asian Development Bank, World Bank, and Japan Bank for International Cooperation (2005), in their joint framework for infrastructure, termed this dilemma as the 'fiscal space' debate, a quandary which has arisen primarily as the result of a decade of fiscal austerity in Latin America, although the problem is relevant in other regions of the world as well. The ADB *et al.* (2005), see lower-income countries where infrastructure needs are high, as well countries recovering from crisis, where attracting the private sector may be slow and incremental process, as particularly vulnerable to these types of threats (p. 35). They do offer some recommendations though, advising countries to ensure that they are fiscally sound before embarking on large-scale infrastructure projects. Furthermore, countries meeting the vulnerability criteria listed above should also determine whether they have adequate public sector capacity and coordination to achieve the required balance between monetary space and other policies (ADB, *et al.*, 2005). However, the ADB (2005) and its associates do not advocate hesitation in regards to infrastructure investment provided the proper mechanisms and conditions are in place. They

claim that a higher public expenditure on infrastructure in developing countries could, if properly balanced with private financing and tariff adjustments, generate even greater fiscal space for future infrastructural endeavors

Aside from public expenditure, infrastructure financing is also provided through loans and grants awarded to countries by official lending and donor agencies like the Asian Development Bank. This is particularly the case in East Asia, where according to the ADB *et al.* (2005), official financing of infrastructure in the region is on the rise again following the 1997 financial crisis. Loans and grants have not been a consistent or particularly reliable source of financing however. In the mid-1990s some official donors and lenders cut their financing of infrastructure projects anticipating greater private investment (a bit prematurely), and because of a view by some that other sectors had more positive impact on poverty reduction (ADB, 2005). Since 1997 however official lending has been on the rise. A major factor in this resurgence has been a reappraisal of infrastructures role in combating poverty. Over the past decade a growing understanding of the benefits of infrastructure in inclusive growth has been accepted by development agencies and non-governmental organizations. Hence as the ADB *et al.* (2005) states, "The depth of the policy and institutional challenges in infrastructure provision, as well as the long-term value of infrastructure reforms, is now better appreciated." This renewal in funds has emphasized a further shift within development communities, away from the private sector's possible replacement of the public sector in infrastructure provision, toward a relationship of mutual assistance between both private and public sector actors. In response official lenders and donors have repositioned themselves, in order to respond to and accommodate the higher profile which infrastructure has achieved, within the international development community. Despite this mini-resurgence however, the role of official lenders and donors is always going to be inadequate in contrast with the immense scale of the developing world's infrastructure funding needs[2]. In its report the ADB *et al.* (2005) reports that in order to maintain relevancy within the infrastructure sector, the challenge for donor agencies is to "focus those relatively small amounts of official financing so that their role is maximized in a variety of efforts, including stimulating experimentation and innovation, supporting efficiency gains, mainstreaming environmental and

[2] A point that is particularly true in East Asia, where some funding estimates are truly staggering, for example, the ADB estimates that Asia will need US$106 billion in new infrastructure between 2006 and 2010. This amount does not include the money necessary to maintain existing infrastructure systems.

social considerations, attracting private investors to share risks with the public sector and building effective institutions to plan, coordinate, and regulate infrastructure services (p. 42)." Thus although, donor financed infrastructure development is not the most prevalent it is still a valuable tool for reforming and modernizing developing countries' implementation and regulatory institutions while helping to provide these countries' people with the infrastructure services they desire.

The private sector has been taking an increasingly larger role in infrastructure provision over the past few decades than in the past, effectively ending the public sector's monopoly over such services in many sectors and countries. As described above, infrastructure has traditionally been the exclusive domain of the public sector, with large, state-owned enterprises (SOEs) being accountable for investment and service delivery (Kirkpatrick and Parker, 2004). However, governments generally aren't the most efficient providers of services in a free market system; thus, the SOE sector has proved to be a costly and cumbersome provider of infrastructure in most developing countries. However, despite inefficiencies and other problems stemming from public provision, these are not the sole motivators for allowing private sector access to infrastructure. Rather, the largest factor driving private sector involvement remains the fact that in many countries the level of investment required for infrastructure development is simply beyond the capacity of its government to provide. In order to plug these growing market gaps many countries have adopted policies to provide private sector access to infrastructure service mechanisms, while seeking to attract local and foreign private investment in the infrastructure sectors (APO, 2001). However, as we have seen there are multiple barriers to private sector access, and in many cases, the low investment returns, coupled with extremely long pay-back periods, have made infrastructure ventures rather unattractive to the private sector (APO, 2001). In addition to this, many countries have been slow to reform their institutional and regulatory frameworks, resulting in policies that are not conducive to attracting private infrastructure investment (APO, 2001).

3.2 Infrastructure and Growth

A prerequisite to generating economic growth and improving a country's productive capacity, infrastructure is the backbone of development in any economy. Good infrastructure can provide vast economic benefits, contributing to productivity improvements and reduction in production costs while encouraging foreign investment and facilitating development in other sectors, like agriculture for example. The lack of good infrastructure has just as a profoundly harmful effect on bottlenecking growth and hindering economic and social development as having no infrastructure at all. In fact, it has been widely acknowledged that economics with higher levels of infrastructure quantity and quality are more advantageously positioned in terms of overall competitiveness compared to economies possessing poor infrastructure (APO, 2001). In their 2006 report *Enhancing Regional Cooperation in Infrastructure Development*, the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) (2006) illustrates this relationship quite succinctly, stating that infrastructure can be considered, if not the engine, then the 'wheels' of economic growth. A car may need an engine to propel it, but without wheels it is not going anywhere either.

Yet economic growth is only one dimension of infrastructure's diverse benefits to society. As a mechanism for inclusive growth infrastructure development is a proven method for reducing poverty in both rural and urban areas. However, meeting infrastructure requirements is not an easy task. Despite its immense value as a development tool, infrastructure is subjected to several criticisms involving, for example, its role in eliminating poverty and the level of access it affords the poor, the role of the private sector in infrastructure provision, as well as a debate regarding the proper balance between 'hard' and 'soft' infrastructure. However, infrastructure's largest uncertainty relates to its sustainability. As it is currently implemented infrastructure contributes to several symptoms of unsustainability, seriously jeopardizing the long-term feasibility of its development while negating the very benefits it seeks to provide[3]. This section seeks to define infrastructure while presenting the major debates and literature regarding the topic. It will culminate with the identification of infrastructure development's ecological impacts, so that in the final chapter of this study a framework for sustainable infrastructure

[3] Please refer to Table 2.1 on page 14 for a list of unsustainability symptoms.

development will be created which seeks to minimize these impacts while promoting and facilitating development.

The links between trade and growth are well documented. From both a supply and demand side point of view, infrastructure development strongly contributes to economic growth. More empirical evidence documenting this link will be presented later in this chapter, but to reference one study, UNESCAP (2006), in their publication on infrastructure regulation using cross section-time series pooled data from over a hundred countries and over a 40 year period shows that growth is without a doubt affected positively by a nation's stock of infrastructure assets. They are not alone in this conclusion and much more empirical evidence linking growth and infrastructure will be presented shortly.

Beyond trade however, and in addition to a wide range of positive externalities, infrastructure has a very clear impact on economic growth. The expansion and efficient functioning of markets is a sign of vibrant and dynamic growth and is predicated on infrastructure development (Ali & Yao, 2004). In many countries markets are fragmented by poor infrastructure connections. Consequently, markets with poor infrastructure can only manage supply and demand within a restricted geographic area. This lack of coordination leads to a distortedly high cost of transporting goods as well as more expensive service provision, and this in turn becomes a barrier to trade and investment (Ali & Yao, 2004). Furthermore, poor transportation and communication services hamper the efficient flow of information among market participants, especially those far from major transport hubs, restricting the economic options and market-power of local people and businesses. Accordingly, a small market size or lack of interconnectivity with outside markets can inhibit the possibility of productivity improvements and commercial activity in under-developed or rural areas (Ali & Yao, 2004). Economists Ali and Yao (2004) argue that the expansion of a well-connected and integrated market system should "improve access to markets, products, inputs and other services, thus reducing transportation and transaction costs and facilitating exchange (p. 5)." Although, economists have acknowledged that many other factors besides infrastructure can affect the extent to which markets are able to function efficiently, it is clear that infrastructure development

is an essential component of interconnected and growing market systems within the developing world (Yao, 2003).

Beyond facilitating market expansion, the availability of infrastructure can have a very noticeable impact on macro-economic areas of demand, such as foreign trade and investment. The role of the transport sector in facilitating economic growth is generally discussed in relation to its contribution to the promotion of domestic trade, yet the increased globalization of development has altered this perception (UNESCAP, 2006). The quality of transport and communication infrastructure, as a point of access to global markets, significantly affects the ability of a country, and particularly the more isolated or marginalized communities within a country, to actively partake in trade (UNESCAP, 2006). Furthermore, if liberalization of trade, a common prescription for developing economies, has the ability to open new markets, then suitable transport infrastructure, reliable delivery and quality service provision are also essential elements in shaping the competitiveness of local products for global distribution and consumption (UNESCAP, 2006).

From a theoretical perspective, economists have for centuries contributed their intellectual capacity in order to devise hypotheses on the possible effects of the construction of infrastructure. David Ricardo was the first classical economist to consider the role of infrastructure in generating economic growth. However, infrastructure's role was not completely solidified until the neo-classical era, and the handful of economists who devoted their work to the subject. Despite these contributions, theoretical analysis of infrastructure is sparse. Most studies prefer to deal with empirical data to analyze impacts, perhaps rightly. As Ahmed and Donovan state in their compilation of theoretical work on infrastructure, development of these hypotheses has been based on the assumption that the creation of infrastructure generates external economies, or widespread benefits (Ahmed & Donovan, 2002).

Traditionally, the conceptualization of infrastructures effect on production within a competitive market economy has been depicted through a graph, which seeks to isolate the change in production efficiency once infrastructure is introduced[4]. Ahmed and Donovan provide

[4] Please refer to Figure 3.1 on page 42.

perhaps the most readable deciphering of the dense economic language normally associated with studies of production. Their description is as follows:

> In a situation of inadequately developed infrastructure, firms or farms are confronted with higher marginal cost (MC1) at every level of production, and, given the market price of their output, produce at Q1. With an improvement in infrastructure, the marginal cost curve shifts downward to the right (MC2), resulting in a total cost savings of area abcd for the earlier level of output, Q1, and an increase in output from Q1 to Q2.

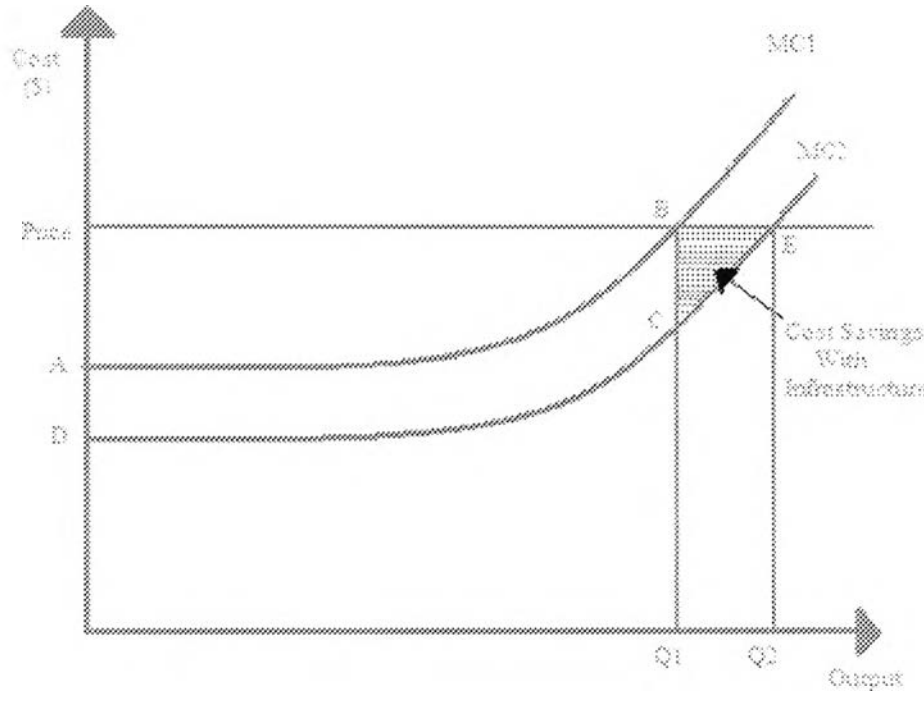

Figure 3.1: Infrastructure Provision and the Efficiency of Production (Lakshamanan, 1989).

This relationship is shown in Figure 3.1. Beyond the technical language however, what this graph illustrates is the clear cost savings effect that infrastructure can have on an economy. The aforementioned cost reductions occur through the interaction of infrastructure with the directly productive inputs of firms/farms (Ahmed & Donovan, 2002). Although this relationship determines cost savings, it can do so in a wide variety of ways. Ahmed and Donovan (2002)

provide a few examples, such as reduction in transaction costs, increased specialization and commercialization, improved dissemination of technology, new combinations of outputs and inputs, better input prices, and improved entrepreneurial power, all achieved through infrastructural investment. This conclusion summarizes the centuries of theoretical analysis of infrastructure's impacts; a more in-depth discussion of that history clearly is in order. What follows is a brief review of the theoretical literature concerning infrastructure development and economic growth. It does not flow in chronological order, unlike previous literature analyses in this study, but rather it is organized around specific dimensions of the relationship expressed in figure 3.1.

The economic benefits of infrastructure are clear. Adequate infrastructure provision, by reducing the costs and risks associated with foreign direct investment, can improve the investment climate of a country by creating jobs, stimulating exports, and generating economic growth. Furthermore, by providing better access to and expanding markets, infrastructure provision increases the economic options of local people, while providing local SMEs the opportunity to access global markets, which increases profits and fuels expansion. Both of these benefits directly contribute to inclusive growth through a need for high-skilled and educated labor in addition to the direct benefits of service provision to local people.

Despite what appears to be overwhelming evidence over the positive qualities of infrastructure development, both to promote economic growth and human welfare in general, several criticisms and debates do exist within the academic discourse on the subject. Most of these criticisms focus around the way infrastructure is provided, including such debates as the value of hard infrastructure vs. soft infrastructure as well as on the merits of private provision. Furthermore, although infrastructure has been shown to be a powerful tool towards achieving inclusive growth, there still remain issues regarding infrastructure access and disparities between developing and developed nations. However the most serious concern regarding infrastructure development relates to the second chapter of this study. As currently implemented, infrastructure contributes to several symptoms of unsustainability, and there remain serious concerns over whether or not growth-centric infrastructure development is a sustainable development path.

The first debate mentioned refers to the dichotomy between two types of infrastructure, 'hard' and 'soft.' Whenever infrastructure is discussed, it is usually with respect to hard infrastructure, such as roads, ports, water, etc. In fact throughout this study I have generally referred to hard infrastructure specifically when discussing infrastructure in general. Yet a focus on just hard infrastructure overlooks a more recent addition to the terminology, 'soft' infrastructure. Soft infrastructure consists of such services such as banking, credit, extension, seed provision, transport, communications and marketing of rural produce, etc (ADB, 1995). Furthermore, some scholars also consider institutional infrastructure, such as agricultural extension, to be a type of soft infrastructure as well (Wanmali & Islam, 1997). 'Soft' infrastructure can also include rules of commerce among neighbors, an essential function to accompany trans-border infrastructure projects. Indeed, for each 'hard' infrastructure sector there is complementary 'soft' infrastructure; and as the ADB notes, unless this is up-to-par with the 'hard' component, the rate of return on investing in the latter will be substandard (ADB, 1995). In regards to the transport sector, types of 'soft' infrastructure can include institutional, legal and other related elements, and the expected benefit of development projects are generally reliant upon investments in both the 'hard' and 'soft' aspects of infrastructure. As listed by the ADB (1995), examples of 'soft' projects to complement 'hard' investment include: The facilitation of transport and trade across international boundaries, specification of transit routes and facilities, and the harmonization of customs procedures, etc.

Another criticism of infrastructure development regards the disparities in infrastructure development between the developed and the developing, and even within the developing world. However, the extent of these disparities can be difficult to gauge because statistics on infrastructural endowment in many developing countries is very meager. Yet, as the ADB points out, even more of a dilemma than a lack of proper data is the actual state of infrastructure in many developing countries and the diminishing resources committed to infrastructure maintenance and development in others (Ahmed & Donovan, 2002). For example, in African countries with serviceable data available, road densities range from 0.01 to 0.11 kilometers per square kilometer of land area; while in Asia, such densities vary from 0.34 to 0.41 kilometers (Ahmed & Donovan, 2002). Furthermore, as might be expected the percentage of paved roads in Africa (10 percent) is much smaller than in Asia (35 percent) (Ahmed & Donovan, 2002).

However it is important to note that these disparities do not just exist between Africa and Asia but within Asia as well. The gaps between Asia's developed nations, Japan or Korea for example, and it's poorest, like Lao PDR and Mongolia are understandably huge[5]. Yet equally large inequalities exist between developing nations. The Philippines, for example, after decades of encouraging and funding infrastructure development within its borders have achieved respectable figures in such areas as water supply access (86 percent) and sanitation access (83), while China, through equally committed investment has achieved nearly 99 percent electricity access for its population (ADB *et al.*, 2005: 9). However in Cambodia sanitation access is as low as 22 percent, and only 3 percent of the population has access to telephones. While in Mongolia, arguably Asia's poorest country, despite up to 90 percent electricity access, only 30 percent of the population has access to proper sanitation facilities (ADB *et al.*, 2005: 9).

	Water Supply Access	Sanitation Access	Electricity Access	Telephone Access	Internet Access
Malaysia	93	-	97	62	34.4
Thailand	93	98	84	50	11.1
Philippines	86	83	79	31	4.4
China	76	39	99	42	6.3
Indonesia	78	55	55	13	3.8
Vietnam	49	25	81	9	4.3
Cambodia	44	22	17	4	0.2
Lao PDR	58	30	41	3	0.3
Mongolia	60	30	90	19	5.8

Table 3.2: Access to Water, Electricity and Telecommunications; by Percentage (2004) (ADB *et al.*, 2005: 9).

However, these disparities do not just exist in regards to access; the level of infrastructure quality also varies significantly from country to country. In terms of overall infrastructure quality, Singapore and Hong Kong dominate the region, with Japan, Taiwan, Korea, and

[5] Refer to Table 3.2

Malaysia follows not too far behind[6]. However from there the drop off is significant. On a scale of 8 the Philippines ranks behind Singapore by 5 points in total infrastructure quality. While Vietnam, China, and Indonesia are not much better off. Furthermore, this data, which was provided by the ADB, doesn't even include the region's poorest countries, thus we're only left to speculate how abysmal the ratings for Cambodia, Lao PDR, or Mongolia would be.

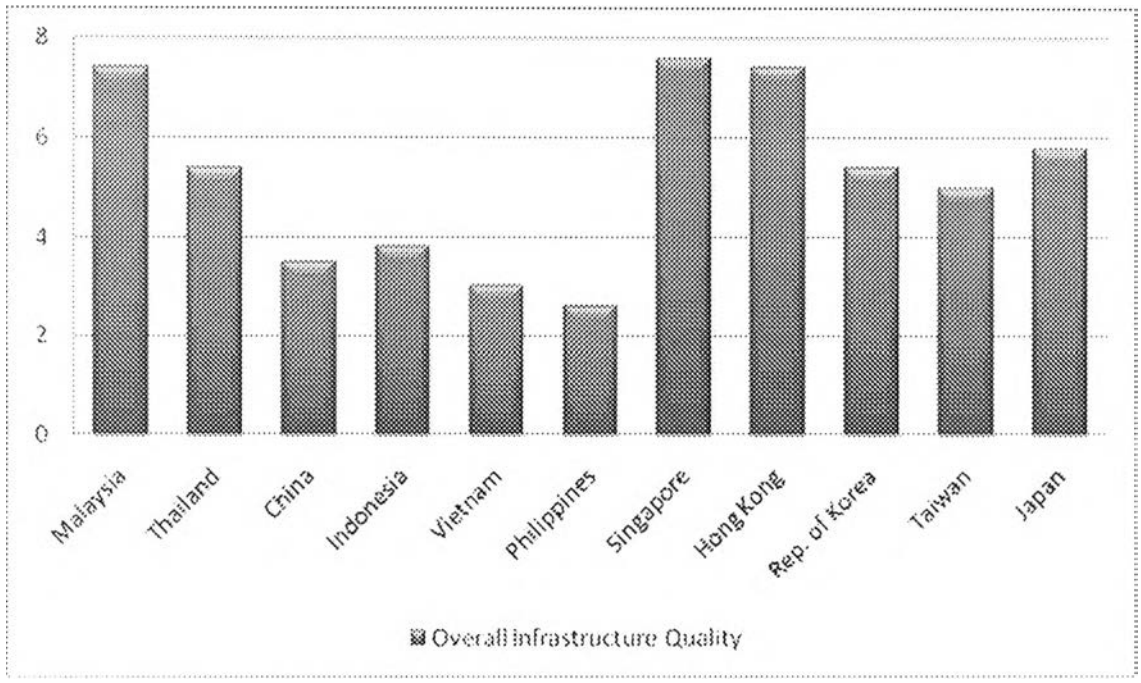

Figure 3.2: Infrastructure Quality Ranking for East Asia, 2003 (ADB *et al.*, 2005: 9).

Although most of these differences can be attributed to sound investment strategies, the disparities are nonetheless shocking. The responsibility to fill these gaps falls on both the deficient countries and Asia's regional developmental organizations to correct whatever poor policies contributed to this problem, a recommendation that is being realized in Lao PDR for example through the initiatives of the ADB and GMS.

[6] Refer to Figure 3.2

3.3 Infrastructure and Sustainability

The sustainability of infrastructure development is a serious concern that could ultimately negate the benefits of such development. In the second chapter the concept of environmental unsustainability was discussed, including a list of signs which indicated unsustainable development[7]. Infrastructure development as it's currently implemented directly contributes to several of these signs, including: Deforestation, species extinction, land degradation, water depletion, and fish depletion. Furthermore, infrastructure development also indirectly contributes to other signs including: Resource depletion (both renewable and non-renewable), and chemical emissions. These signs are interrelated and for the most part are predicated on my established definition of unsustainability, the non-maintenance of the natural capital stock.

Deforestation is perhaps the most significant of infrastructure's unsustainability symptoms. The World Resources Institute (1998) estimated that by as early as the mid 1990's Earth's forest cover only just over half what it was in pre-agricultural times, while the amount of undisturbed, primary forest was only about a fifth of the original amount. Sadly, the numbers have continued to plummet since. The United States, not accounting for Alaska, has preserved only 5 percent of its original forests, while Europe's forests are practically all gone (Brown, *et al.*, 1991). Furthermore, the large expanses of remaining primary temperate forests in Canada and the former Soviet Union, which to this point had been saved only by their remoteness, are now also being felled, with estimates putting Canada's loses alone at 200,000 ha per year (Brown, *et al.*, 1993).

However, the most rapid deforestation has occurred in tropical countries where only half the original area of forests remains, while over half of this has already been logged or degraded in some form (Brown, *et al.*, 1991). Moreover, according to the WRI (1992), the rate of tropical deforestation markedly acclerated during the 1980s, increasing between by 1991 by over 50%. And these are just average figures, in some countries deforestation has continued at an even faster rate. For example, Indonesia's rate has quadrupled since 1970, by the mid-1990s reaching an annual destruction rate of 1 million ha (Ekins, 2002). Additionally, Thailand's forest cover

[7] Please refer to Table 2.1.

between 1961 and 1988 plummeted from 55 percent to 28 percent (Ekins, 2002). Between 1990 and 1995 deforestation rates in developing countries averaged a shocking 13.7 million ha per year (WRI, 1998). Beyond the loss of forest cover, deforestation has widespread negative environmental side-effects, linking it to many of infrastructure unsustainability symptoms, including water depletion, species extinction, climate change, etc.

Infrastructure development, largely through the transport sector greatly contributes to the loss of our planets forests through a variety of ways. First, road construction requires the clearance of trees in order to facilitate construction, however too frequently many more trees are cut down then required. Furthermore, by opening up previously rural and inaccessible areas to growth hubs infrastructure development facilitates deforestation. Once a rural highway has been built, including its accompanying access roads, illegal logging quickly follows; clearing what had previously been sheltered forest. Thus in many developing countries deforestation rates have consistently risen along with the level of rural road access throughout the country. Deforestation has been an acute issue in the GMS and will be discussed in greater detail later on.

In addition to the loss of our planets forests, the current rate of species extinction is also on an unprecedented scale. As the World Bank (1992) notes, "The complex web of interactions that sustains the vitality of ecosystems can unravel even if only a small number of key species disappear (p. 59)." Unfortunately, due to a wide variety of consequences associated with human development several species a year are lost, with, many more on the margins of survival. According to the World Bank (1992) estimates, the numbers of identified species are fewer than 1.5 million, but scientists predict that over 30 million actually exist, of which over 90 percent are insects. Thus, when modern science has only been able to account for one twentieth of the planets estimated species, figures on extinction rates are obviously just little more than informed conjecture. However, Brown *et al.* (1993) cites some sources which puts the minimum loss of invertebrate species at 50,000 per year. One certain trouble spot those is our planets tropical forests, which cover 6-7 percent of the Earth's land surface and contain 50-90 percent of all species (Ekins, 2002). Ekins (2002) provides estimates which show that up to 40 percent of all species in the rainforests of South American and Africa look likely to be extinct by the early years of this century. Furthermore, according to the World Resources Institute (1998), around 34

percent of the world's fish species are also threatened with extinction. What's more, additional sources classify as 'threatened' 42 percent of Europe's mammal species, 45 percent of its reptiles, 30 percent of its amphibians and 52 percent of its freshwater fish (Ekins, 2002). As Ekins (2002) points out, the situation is not good, all the evidence leads to the unavoidable fact that the size and diversity of remaining natural ecosystems is rapidly in decline and in many instances this decline is accelerating.

Infrastructure development contributes to species extinction much in the same way in contributes to deforestation, by opening up previously inaccessible areas to human expansion. Rural road expansion exposes wildlife populations to the trade in meat and animal products that accompanies such projects. Furthermore, deforestation, another symptom of infrastructure threatens to destroy the habitats of native species, jeopardizing the biodiversity of our planet.

Land degradation has been another serious side-effect of human development. For instance, according to the WRI (1992) over the past forty-five years nearly 11% of the Earth's total vegetated soils have become degraded to the point that their original biotic functions are damaged, while in many cases reclamation could be costly or impossible. Additional figures from the WRI (1998) state that by as early as 1990 poor agricultural practices had already factored in to the degradation of 562 million ha, which accounts for about 38 percent of arable land worldwide, with an further 5 to 6 million ha lost each year since to severe soil degradation. Furthermore, as of 1993, almost 500 billion tons of topsoil had been lost since 1972; a process that persists at a rate of 24 billion tons a year, and threatens to render vast amounts of agricultural lands unusable (Brown, *et al.*, 1993). According to Ekins (2002) 'major soil threats' are classified as: water erosion, nitrates and phosphates, soil compaction, organic matter loss, salinization, and water logging (p. 16). The activities contributing to these threats and thus leading to land degradation are deforestation, overgrazing and agriculture (Ekins, 2002).

Infrastructure development contributes to land degradation in two ways. Poor infrastructure construction can cause an array of harmful environmental side-effects including erosion, soil depletion, run-off, etc. Furthermore, the pollution from un-regulated or monitored

construction sites can further contribute to land degradation. Also, the process of degradation, spurred on by road construction is also a primary contributor to land degradation.

Another consequence of infrastructure development is water depletion and the degradation of water quality. Over the past 50 years, global water use has climbed by a factor of three or by 50 percent per capita. According to Brown *et al.* (1993) the usage breakdown is as follows: 69 percent is used for agriculture, 23 percent for industry and 8 percent for domestic uses (p. 22). Further projections place water usage for irrigation to increase by 50-100 percent and for industry by 100 percent by 2025 (WRI, 1998). Domestic use is also projected to rise sharply as more affluent populations increase their consumption and the ever growing threat of population pressure pushes some sources to their breaking point. Overall, water usage is currently rising at a rate of 4-8 percent per year around the globe (Ekins, 2002). As Ekins (2002) points out, such increases can only serve to worsen already serious developments in some regions of falling water tables, depleted groundwater resources and insufficient supplies.

For instance, in Beijing water tables have been dropping 1-2 meters per year and a third of the wells have run dry, yet demand continues to skyrocket (Brown, *et al.*, 1993). Furthermore, the countries of the North Africa and the Middle East face a similar situation. Nearly all of the regions available water supplies are being utilized, yet populations in some of the countries have been projected to double every twenty-five years (Ekins, 2002). Furthermore, the potential for conflict over strained trans-boundary water sources is very real. For example, Ekins (2002) cites Egypt, where86 percent of the countries water comes from the Nile, whose waters originate in eight countries upstream. Additionally, in Europe, almost half of the continents countries have 'low, very low or extremely low' water availability, while twenty different countries receive a significant share of their water from trans-border sources (Ekins, 2002: 17-18).

Infrastructure depletion contributes to water depletion through poor construction practices. These practices can divert water sources, enhance erosion and increase sedimentation which can choke rivers and streams, and inhibit the proper seepage of groundwater into the water table. Deforestation greatly contributes to these processes. Furthermore, dams on trans-boundary rivers, a common occurrence in East Asia, are a sever threat to the water supply of downstream

nations who have no control over the quantity of water flowing through their rivers. A fact being illustrated through China's continued damming of the Mekong River.

Infrastructure development can also contribute directly and indirectly to the depletion of our planets fisheries, which are already in great peril from unrelated factors. The largest contributor to this problem is overfishing. Throughout the 1990s global fish catches declined, almost yearly (Brown, *et al.*, 1995). In fact, as early as 1989 every single oceanic fishery was being fished at or beyond its limit, with thirteen of the fifteen largest experiencing steep declines (Brown, *et al.*, 1996). Since 1977 over 30 percent of US fish stocks have declined (WRI, 1992). While in the UK Ekins (2002) reports that by 1996, nearly half of the currently fished stocks had spawning populations which were estimated to be at a level where there was a very real risk of stock collapse. Furthermore, in 1992 Canada was forced to react to dwindling catches off Nova Scotia and Labrador by banning all cod and haddock fishing in the area for two years, despite the significant economic value of the regions fishing industry (Brown, *et al.*, 1993).

Yet as Brown et al. (1993) notes, is that the ongoing pollution and degradation of coastal habitats, where 90 percent of the world's marine animals reproduce, is perhaps a larger threat in the long-term then overfishing. For example, mangroves, wetlands and salt marshes are being rapidly cleared for urban, industrial and recreational uses. Tropical countries have faced the worst destruction, losing over 50 percent of their mangroves over the past couple decades (WRI, 1992). Furthermore, according to the WRI (1992), much of the world's sewage is still dumped untreated into coastal waters, augmenting pollution from other sources like fertilizers and chemicals commonly used in agriculture. As Ekins (2002) notes, these trends are quite ominous for the food supplies of many tropical developing countries, in which over 60 percent rely on fish for 40 percent or more of their protein.

Infrastructure can contribute to fish depletion in three ways. First through water depletion and the erosion of water quality spurred on by construction and deforestation. Secondly, through the destruction of coastal habitats like mangrove forests etc., motivated by the construct ruction of infrastructure networks like roads, ports, airports, etc. And finally, by projects which block naturally occurring water flows, like dams with rivers, and on a smaller scale, roads with

streams, can disrupt the natural feeding or mating habits of fish populations, severely jeopardizing their survival. The case of the Puk Mun Damn in Northeastern Thailand is the best example of the former occurring in practice.

The final contribution of infrastructure development to the degradation of our environment is through its direct and indirect contribution to climate change. It has been well documented that human activities, particularly those of an economic nature, are significantly increasing the atmosphere's greenhouse gases, by the emission of CO2 from the burning of fossil fuels and deforestation, but also of chlorofluorocarbons, methane, nitrous oxide and other gases (Ekins, 2002). According to figures cited by Ekins (2002), the level of carbon dioxide in the earth's atmosphere has risen over 25 percent since pre-industrial times owing to human actions; while methane concentrations have nearly doubled over the same period.

Although the effects of global warming are nearly universally held to be negative, debate does exist to an extent over what those effects may be. Ekins (2002) notes several possible consequences, including:

- The extinction of species that fail either to migrate or adapt to changed climatic conditions;
- Loss of agricultural productivity where weather patterns become hotter, drier or more erratic than is agriculturally desirable;
- Sea-level rise with inundation of coastal zones;
- A greater frequency of extreme weather conditions;
- And an increase in vector-borne diseases.

Emissions are generated mainly from the burning of fossil fuels, deforestation and various agricultural practices (Ekins, 2002). Infrastructure development directly contributes to climate change through deforestation. Trees are the natural absorbers of carbon in our atmosphere, as we cut down our forests our planet loses its capability to recycle carbon, greatly contributing to global warming. Furthermore, infrastructure also contributes indirectly by facilitating the expansion of emissions heavy sectors like transport and energy. Until both of those industries are made carbon neutral then infrastructure will continue to contribute to climate

change. Unfortunately this effort is largely beyond the scope of infrastructure development, relying instead on mankind to change its consumption habits before disaster strikes.

Thus infrastructure development directly and indirectly aggravates all of these unsustainability symptoms. In fact, one could argue that infrastructure, as an engine for growth-centric development contributes to all of the symptoms mentioned in Table 2.1, including those not mentioned above. However, one connection that each of these points share is a link to deforestation. Deforestation, as the most significant consequence of infrastructure development, is a major cause of land degradation through soil erosion and pollution, water depletion via increases in sedimentation and runoff as well as of species extinction and global warming. Although efforts to target each of these symptoms individually could yield some success, the most efficient strategy to make infrastructure sustainable would focus on their common cause, deforestation.

3.4 Tools for Sustainability

The governments and banks which fund new infrastructure development are acutely aware of the environmental damage that they are causing. Fortunately tools do exist for both the developers, and third party monitors, to mitigate a projects impact. The two most powerful are Environmental Impact Assessments (EIAs) and government regulation. If utilized capably and in tandem the future sustainability of infrastructure development is brighter, but if not the status quo of ongoing environmental degradation will continue.

Environmental Impact Assessments' are created by environmentalists and environmental agencies to assess the ecological and limited social impacts of a proposed development project or plan. These analysis' are meant to be used by policy-makers to properly consider the cost-benefit ratio for new projects. EIAs are meant to be extremely in depth, encompassing all potential effects of a proposed project, including but not limited to air and water pollution effects, erosion, soil contamination, deforestation, wildlife risks, geological hazards, negative

health risks, and noise pollution. According to the Community Guide to Development Impact Analysis, EIAs can achieve four key objectives (Edwards, 2007):

1. Promote communication among local officials, developers, community leaders, and citizens about the nature of the proposal and potential impacts on the local environment.
2. Ensure compliance with all relevant and appropriate environmental laws and regulations (e.g., storm-water management, compliance with wetland and floodplain regulations) during construction and operation of the new development.
3. Ensure consistent and fair review of development proposals by applying a systematic review process that includes environmental assessment.
4. Provide a forum for exploring alternatives to the proposed development or strategies to mitigate impacts, if necessary.

The World Bank's assessment goals are a bit shorter and to the point, however they reflect the same sentiment as those presented above. According to the World Bank environmental assessments are useful tools for helping avoid or minimize the undesirable impacts of a project. They achieve this by (WB, 1994)

1. Identifying potential adverse impacts and assigning their significance.
2. Recommending modifications in project design to avoid or minimize these impacts.
3. Designing mitigation, management, and monitoring plans to reduce or manage adverse impacts or compensate for those that are unavoidable.

Yet no matter however you put it, EIAs stand as a valuable step towards ensuring the sustainability of a planned infrastructure development project.

EIAs have been utilized by the major development banks for well over a decade by now, thus through practice, the process has slowly been enhanced over time. The World Bank (1994), for example, claims that its assessment quality has has improved significantly in such areas as impact identification and analysis, public consultation, mitigation, monitoring, and management

planning. However there remain considerable limits to the effectiveness of these assessments. In theory environmental assessments can influence projects in a few ways, including (WB, 1994):

1. Being a component of the project identification and design process, thus contributing directly to other feasibility and technical surveys.
2. Being utilized to investigate and propose alternatives (for example, in design, implementation, or location) even if EIA is not a fundamental part of a specific project's preparation.
3. Recommending supplementary measures or components to augment the project's environmental footprint.

However, in practice EIAs rarely consider alternatives for projects; because in fact once the assessment has actually been commissioned it is already too late for many parties to willing roll back progress on a given project. And, even when alternatives are included, they are rarely seriously considered because they are generally less attractive (or less lucrative) than the original project plan. The World Bank (1994) is all too aware of this failing, lamenting in one of its reports on the subject, that in many cases their EIA's still contain only short portions on alternatives and do not exhibit a serious attempt to analyze them from an environmental perspective.

Yet the World Bank (1994) is also quick to offer excuses for these short-comings, claiming that the use of EIAs can be difficult for a variety of reasons. For example they note timing as a serious constraint because in many cases the Bank's project preparation process may not be aligned with the borrower's planning schedule. Thus in many cases like this the only alternative available to the donor organization is whether or not to finance the project, and the bank's rarely choose the latter option. Furthermore, the Bank (1994) cites the difficulty and technical skill needed in order to fully address the impacts of a project in an EIA. Many countries do not possess the capacity to conduct a survey of this magnitude, thus in many cases specialized external consultants may therefore be required, greatly increasing the costs of the assessment.

A final difficulty in regards to conducting a proper assessment is the costs that it can add to the overhead of a project. According to the World Bank (1994), the normal cost range for

large-scale project assessments can be between $60,000 and $200,000, or about 1 to 10 percent of a project's preparation costs. The cost of an EIA is largely predicated by a range of factors including (WB, 1994):

- The extent to which international consultations are used.
- The complexity of the project and its potential impacts.
- The depth, scope, and duration of date collection and analysis.
- How many separate EIA's need to be prepared for different subprojects.

Continuing on the second point, in projects where multiple and complex environmental externalities can be expected, and when essential ecological data is lacking, a data collection period of one year or more is generally necessary (WB, 1994). Thus, more elaborate EIAs for more complex projects will inevitably cost significantly more to conduct properly, and when a project needs to cut down on its budge unfortunately the quality of the assessment frequently suffers. Yet with these shortcomings aside, an Environmental Impact Assessment remains the most valuable tool to identify and minimize the harmful environmental effects of a development project, provided that it is properly conducted and its findings are actually acted upon.

Before Environmental Impact Analysis' were used in the development planning process the ecological impact of infrastructure projects was largely unknown until after the project was complete. Thus, nations have had to deal with adverse environmental effects such as flooding, soil erosion, deforestation, disrupted animal migration patterns, and polluted air and water among others, all directly caused by human development. Although Environmental Impact Assessments don't necessarily prevent all negative environmental effects related to development projects they affect decision-makers cost-benefit ratio allowing nations to undertake more responsible and sustainable development planning, a point that will be discussed in more detail shortly.

Regulation is a multi-dimensional tool for monitoring infrastructure. Brook and Irwin (2003) note that during the 20th century were much less reluctant to flex their regulatory muscles and maintained quality control primarily through public ownership of service providers. Yet in recent decades governments have been retreating from ownership and focusing on improving

their ability to independently regulate private companies, as the regulatory school of thought has largely determined that combining ownership, regulatory, and operational responsibly generally leads to poor performance in all aspects (Brook & Irwin, 2003). Finally, as governments have adjusted to their new role as independent observers, modern regulatory systems have to comprise three distinct, but mutually supportive, elements (Brook & Irwin, 2003):

- A set of regulatory rules embodied in laws, licenses, contracts, or similar instruments that define the boundaries of acceptable conduct.
- One or more regulatory bodies charged with administering and enforcing those rules.
- A set of regulatory processes undertaken or managed by the regulatory bodies in discharging their responsibilities.

The system described above is utilized in the United States, and has also evolved into the global standard for infrastructure regulation. Although details vary between sectors and states, there are several broad principles that should shape regulatory systems for infrastructure (Brook & Irwin, 2003). The points discussed below represent in many ways the solution to Highway 9, and other's monitoring issues. By applying these principles government regulatory capacity can be empowered enough to allow states to independently monitor their own infrastructure projects more effectively.

The first point to note is that although once capable regulatory mechanisms are established restraint is essential, and intervention should only be done sparingly. This is important because, as Brook and Irwin (2003) note, for most of its history infrastructure regulation has been characterized by unnecessarily heavy-handed intervention, including regulatory barriers to sustain monopolies and intensive regulation of dimensions which should be left to market forces, like prices and other such attributes of service delivery. Yet this method proved inefficient, and by the 1980s governments began to realize that such stiff regulation can involve substantial costs, including the direct costs of administration by the government and of compliance the part of contractors (Brook & Irwin, 2003). Furthermore, in what seems to be a theme regarding infrastructure development in general, the indirect costs of government regulation can be even more significant. Brook and Irwin (2003) include rigidity, stifled

innovation, distorted incentives, rent-seeking behavior, and other deficiencies flowing from the political economy of regulation and the inevitable asymmetry in information between regulators and firms as examples of these indirect costs. Thus, in addition to market failure, the concern of regulatory failure became very real as well. For this reason, the scope of the government's regulatory mandate should be limited.

As mentioned above, regulation of infrastructure quality should be the prime concern of government regulatory bodies. Regulation of infrastructure quality, in this case is primarily over concerns regarding environmental degradation and reliable service provision, however it has also be justified by concerns over monopoly abuse, as well as safety, health, or other consumer protection concerns (Brook & Irwin, 2003). However, the act of introducing competition into the contract bidding process goes a long way towards limiting monopoly power. The primary way for regulatory bodies to ensure quality is to set quality standards, either on a national scale or on a project to project basis (EIA's are a significant dimension of this process). Once standards are in place it is also the government's responsibility to monitor the project and ensure that their standards, as well as any principles agreed to during the project planning phase are being met.

Unfortunately the setting of standards can have an adverse affect on the price of implementation and provision. This is particularly true in cases where regulatory bodies adopt standards that are either to stringent or just unrealistic based on the circumstances. Thus it is important for regulators to pay close attention to the potential costs involved with regulating quality, including such unintended consequences that may arise (Brook & Irwin, 2003). Brook and Irwin (2003) note that in many developed nations, regulators have begun to conduct regulatory impact assessments before imposing new rules while also reviewing existing rules frequently in order to ensure that the expected benefits exceed the expected costs. Thus it is vital that good communication be maintained between regulators and contractors during the long planning phase of a project so that knowledge regarding environmental impacts and costs can be shared and integrated into the projects own cost-benefit analysis.

3.5 Conclusion

Over the past chapter I have illustrated the importance of infrastructure development to generating economic growth and development. Infrastructure generates economic growth through a variety of functions, such as reducing the cost of inputs, facilitating and encouraging investment and promoting trade. Furthermore, infrastructure also contributes to inclusive growth and poverty reduction by increasing incomes and improving access to services for the poor. Thus infrastructure development has been accepted almost universally as a key contributor to the welfare of all mankind.

Yet, although infrastructure is a major contributor to economic growth it also contributes, directly and indirectly, to several unsustainability symptoms of the global economy. My definition of sustainability focuses on the concept of natural capital, declaring that sustainable development is development that has not occurred at the expense of the natural capital stock. Current infrastructure development, through its destruction of natural environments via deforestation, etc. clearly does not meet this standard. Thus infrastructure development, as its currently implemented, along with the vast majority of human activities on this planet is not sustainable for the future.

Yet this does not mean we should forgo infrastructure development as a tool for growth. The tools exist to minimize infrastructures harmful ecological effects. More rigorous and strict application of environmental impact assessments can streamline the planning phase of a project while ensuring sound and sustainable implementation. Additionally, capable government regulation can serve the purpose of monitoring and enforcing EIAs while upholding the accountability of those fueling infrastructure growth and development. However, as the following case study will illustrate, these tools have not been utilized properly. In the next chapter I will apply the tenets of sustainable development to current infrastructure development practices in order to create a framework for reducing the impact of infrastructure development on the environment, without significantly halting or slowing its implementation. Because, despite the immense economic importance of infrastructure development and growth, only proactive

measures can reverse what many see to be a series of unstoppable ecological disasters in the future.