Spatial Analysis of the Effect of Absenteeism on Education Quality in Maynas, Peru

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

This thesis examines the effect of absenteeism on education quality for primary-aged public school students in the Department of Loreto, Province of Maynas, situated in the Amazonian region of north-eastern Peru. It also examines the underlying reasons for absenteeism, with a focus on the contribution of childhood morbidity and socio-economic and environmental context to absenteeism, using both gender- and grade-based analyses of student level absenteeism data collected from a sample of schools in the study area. A five-component model with multiple individual indicators measuring each component of education systems defines the concept of education quality as it relates to the analysis in the thesis. The model has been demonstrated in previous research to be effective in explaining variations in education quality in Peru and elsewhere. However, the model has not been applied to this important yet under-researched area of education assessment, namely student absenteeism (at the student and school level) and its effect on education quality. In addition, spatial variations in absenteeism, based on the geographic distribution of the schools over the study area, are evaluated. This analysis allows spatial regularities or spatial randomness to be established for both absenteeism and education quality in the study area. Identifying spatial clustering of public primary schools where a high rate of student absenteeism contributes significantly to explaining overall low levels of education quality can provide education policy planners and decision-makers with insights into causal processes that need to be addressed through planned interventions in the education system.

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Chapter 1

Introduction

The role of education-based processes in creating social, economic and cultural opportunities is well known, especially with respect to continuous access to quality education during childhood. However, access to primary education is neither universal nor guaranteed for a significant proportion of the world's children. Economically disadvantaged children in the world's developing nations who are not afforded the benefits of continuous access to quality education due to their socio-economic circumstances are deprived not only of the direct benefits of education, but are also deprived of the education-based foundations that underpin future opportunities later in the life cycle.

The United Nations Educational Scientific and Cultural Organisation (UNESCO) has long recognised this problem, and in 1990 brought the issue to the forefront of global education policy and planning at the World Conference on Education for All (WCEFA) in Jomtien, Thailand. This conference produced the Education for All (EFA) declaration and initiated the EFA movement. The intention of this movement was to establish basic primary education for all children and to reduce substantially illiteracy (including adult illiteracy) before the end of the 20th century. The EFA declaration set out the movement's goals, including (i) promotion of education as a fundamental right, (ii) improvement of the quality of education, and (iii) experimentation, innovation, and policy dialogue among education stakeholders (UNESCO, 1990). Above all, the WCEFA confirmed and strengthened the growing international consensus on the need for setting aggressive global education targets for the benefit of both individuals and nations.

The WCEFA has set the international standard for education planning and policy implementation despite not achieving the primary goal of access to primary education for all the world's children by the target year 2000. Thus, the delegates reconvened at the World Education Forum in Dakar, Senegal in 2000 in an effort to restate and reconfirm the goals of the EFA movement. This meeting produced a follow-up declaration to the 1990 EFA declaration, namely the Dakar Framework for Action (DFA). The purpose of the DFA was to reaffirm the international community's commitment to achieving the goals of

EFA, again including a call for significant reductions in both adult and youth illiteracy. The conference also set a new target date of 2015 for the realisation of the original EFA goals, expanded the movement's horizon, and elevated the international education discourse from the prosaic 'education for all' to a more egalitarian notion of the place of primary education in development encapsulated by the term 'universal primary education' (UPE).

The term UPE was intended as an acknowledgement that access to education should be colour-, culture- and gender-blind (UNESCO, 2000b). Additionally, although the EFA declaration had called for the monitoring of education systems in both the developed and developing world using statistical indicators, and had laid out a quantitative model upon which to evaluate education systems, the DFA was the first declaration to acknowledge explicitly that the quality of the education delivered, above and beyond mere access for children to schools and schooling, was essential for real progress to be made in the achievement of UPE. The DFA fell short, however, of explaining concretely what constituted a quality education and how education systems in developing countries especially were to attain this lofty goal given their political and economic realities (UNESCO, 2000b).

Education planners and policymakers in developing countries were directed by the DFA to consider the existing conditions and state of education systems (as measured by a set of 18 statistical indicators selected by the original EFA partner organisations) as well as the specific local needs of students and communities when developing strategies for improving their education systems. Thus, implementation of the expanded DFA goals required specific local knowledge on the part of education policy planners and decision-makers about problems and needs relative to various aspects of education systems within their jurisdiction. This approach to improving education systems was dependant on the ability of education planners to assess specific factors related to education quality and consider how these factors vary at the local level. This marked a significant departure from the original EFA focus, which emphasised evaluation and comparison of education systems solely at the national and super-national regional levels (UNESCO, 2000b).

As of 2004, it was recognised that the 2015 deadline, while seemingly a long way off, was approaching fast without substantive improvements to national education systems, especially where these improvements were most needed. Thus, the Fast Track Initiative (FTI) was introduced at this time to address the concerns of the EFA delegates and partner organisations. The FTI was not a new declaration or an expansion to previous declarations as the DFA had been. It was instead an addendum to the DFA declaration designed to accelerate progress towards the core goal of UPE on a country-by-country basis by assisting the international development community, donor countries, international development agencies and especially the world's poorest countries in achieving the goals set out in the original EFA declaration and the DFA by the 2015 deadline. The FTI was intended to accomplish these goals through the implementation of a partner system in which donor and recipient countries were matched based on their opportunity and needs profiles. It was hoped that exclusive partnerships would increase direct aid to education systems and would increase accountability for the funds targeted to the EFA movement for both donor and recipient nations (UNESCO, 2002).

Thus, the FTI attempted to place specific requirements on both the donor and recipient countries such as increased accountability and transparency that allowed for more targeted programmes to be developed to meet local needs while simultaneously addressing the donor country's domestic priorities (World Bank, 2004b). The FTI also once again elevated the international education discourse by introducing the concept of 'universal primary completion' (UPC). This new term was intended to solidify the understanding of the need for access to education that meets some minimum standard of quality while still ensuring that the goals of EFA and the DFA were applied to all children equally, regardless of gender or ethnicity. Moreover, the term attempted to capture an understanding of the continuous nature of education and suggested that the associated benefits of access to education accrued not only from universal access to quality education but also from continuous and uninterrupted attendance in the education system (World Bank, 2004b).

Overall, the net results of the EFA movement to date have been recognisable improvements in education systems for many of the world's developing countries. For example, countries such as Peru in the Latin America and Caribbean (LAC) region have made significant advancements with respect to the access to and universality of education for children through the application of the recommendations of the EFA declaration, the DFA and the FTI. These recommendations include increased state funding for education programmes, changes in the planning and management of education, and decentralisation of education authorities. Prior to the implementation of the recommendations contained in the EFA declaration, education planning in Peru was undertaken only at the national level. This reflected in part the historically centralised nature of political structures common to developing countries such as Peru as well as the limited financial and human resources available in these countries to invest in education planning (UNESCO, 1990).

Specific improvements to education in Peru as a result of the implementation of EFA recommendations, such as the devolution of education responsibility to decentralised education authorities, include increased attendance, reduced youth and adult illiteracy, increased university enrolment and improved education infrastructure (World Bank, 2001). In addition, rapid growth in the capacity to collect, maintain and analyse school-based education information as a result of the adoption and penetration of information and communication technologies (ICTs) along with the increased capacity and ability to evaluate the education system using this information have also played a significant role in these improvements. For example, the growth of education information resources has revealed to education planners quantifiable and recognisable linkages between education planning and policy programmes designed at the national level and the resulting affect on the quality of local level education delivery. Assessment and understanding of this complex relationship and the impact on the delivery of quality education was not possible prior to the structured monitoring and data collection programmes implemented as part of the recommendations of the EFA movement.

Most notably, education planners have recognised the role of exogenous contextual factors on children's scholastic performance. These factors include socio-economic status, quality of life, environmental factors, and perhaps most importantly student morbidity. While seemingly uniform at high levels of aggregation, such as at the national or provincial levels, these factors can vary considerably between local education management units and at the level of individual schools and communities. Education planners also recognised that socio-economic and environmental contextual factors have a greater impact on overall education quality and student performance in areas where children must contend with increased hardships such as areas of extreme poverty and/or environmental extremes. Simply stated, EFA-mandated monitoring of education systems has revealed that the effect of local contextual realities on education quality can only be recognised and addressed properly by decentralised and locally empowered education authorities in the presence of relevant, useful and current information.

Unfortunately, the information collection methodologies of state institutions in developing countries such as the *Ministerio de Educación* (MINEDU) and the *Instituto Nacional de Estadística e Informática* (INEI) in Peru have focussed almost exclusively on limited 'snapshot' year-end data collection and have thus not been able to take full advantage of the value inherent in the continued monitoring of education-based processes. These year-end data, while useful to education planners and decision-makers, are typically never analysed below the national or provincial level of aggregation. This methodology persists despite the rapid growth and adoption of ICTs throughout the country and the recognition of the significant contribution of local contextual effects and processes to student performance, preparedness and scholastic achievement. Clearly, this approach to education system evaluation does not address adequately the continuous nature of education processes and cannot take into account linkages between contributory factors that occur both within and between school years such as instances of student absenteeism and subsequent outcomes such as grade repetition and attrition.

Despite these shortcomings in the accepted monitoring and evaluation paradigm it is possible in principle, thanks to the continued efforts of the EFA movement, to develop a methodology for school and student level analysis of phenomena within the Peruvian education system (such as absenteeism) and assess the effect of these phenomena on education quality. The education-based and socio-economic contextual data that exist currently in Peru, due to the requirements imposed as part of the EFA process, can be extended and enhanced by collected sample data and combined and assessed in novel ways such as with spatial analytical methods. These analyses can demonstrate to education policy planners, as well as other education stakeholders such as teachers and parents, the value of and need for accurate and complete data collection for the proper and complete evaluation of education systems at the local level.

1.1 Objectives

This thesis has three primary objectives. As suggested in the above discussion the role of absenteeism in the process of education is a poorly understood and under-researched aspect of education systems in general. This is true especially in the case of developing countries, including Peru. Poor understanding of the influence of disruptions to the learning process and the effect of these disruptions on the quality of education that students receive ultimately undermines the ability of education policy planners to deliver quality education that is sensitive to local needs and contexts. Hence, the first objective of the thesis is to gain a comprehensive understanding of the role of education in the development of nations and individuals. A five-component model of education systems, which has been applied successfully in prior research (Peters, 2002, Leahy, 2005), is introduced as a framework for assessing education systems, and the quality of education delivered in these systems, in order to achieve this objective.

The second objective is to gain a comprehensive understanding of the reasons for and contributory factors to absenteeism (with a focus on the role of childhood morbidity and socio-economic and environmental context) and to assess the effect of absenteeism on education quality at the school and student level. It is expected that these factors are statistically significant contributors to overall absenteeism within the study area due likely to specific socio-economic and environmental conditions such as high levels of poverty and frequent outbreaks of tropical diseases such as malaria, dengue and yellow fever. Access to education as well as the quality of the education delivered and the opportunity to attend continuously without interruption are all thought to be critical considerations in the evaluation of education systems (UNSECO, 2005c). Thus, an indicator of absenteeism, which measures interruptions to education processes, is proposed as a valuable indicator which could be used to assess the performance of education systems and thus the quality of education delivered at the school and student level. To achieve this objective an education management information system (EMIS) is developed to link education quality, as defined by contextual and scholastic indicators from the education system model developed as part of the first objective, to student absenteeism. This objective addresses the ability to use the existing data resources collected and maintained by the MINEDU and the INEI as part of the EFA process and other international and internal campaigns by transforming these data into meaningful information relevant to the assessment of the effect of absenteeism on education quality at the school level.

The third objective is to examine systematically the spatial patterns that exist in the relationship between education quality and absenteeism. This is accomplished using geographic information systems (GIS) and spatial analytical methods which can be used to examine spatial relationships, dependencies and patterns in absenteeism and education quality for the schools in the study area. The purpose of this analysis is to develop a spatial data model to identify the spatial relationships between the contributory causes to absenteeism as well as between absenteeism and education quality. This analysis can be used to identify clusters of schools where high levels of absenteeism contribute to low education quality (e.g., "hot spots") or, conversely, where high levels of absenteeism do not significantly contribute to (i.e., reduce) the level of education quality (e.g., "cold spots"). Analysis of the characteristic differences between these areas leads to the development of planning policy recommendations for intervention programmes with the goal of reducing absenteeism and thus increasing the overall quality of education.

1.2 Structure

Chapter 2 provides the context for this thesis by discussing the nature of education and its importance in the development of individuals and nations. This is followed by a brief history of the EFA movement and related efforts at the international level to achieve UPC. A five-component model of education systems is introduced in this section as a basis for discussion of the nature and structure of education systems and as a framework for the analysis of education quality. Subsequently, this model is used to assess the existing state of national education systems in developed and developing countries. Next, absenteeism is defined and discussed and its role in education processes is explored. The chapter concludes with a discussion on the interactions between health, socio-economic context, and absenteeism as well as a discussion of the role of health in human development.

Chapter 3 discusses the importance of information in general and spatially referenced information in particular for supporting education policy planning and decision-making. The first section of the chapter discusses the information needs of education systems, with a specific focus on education systems in developing countries. This is followed by a discussion of relevant spatial technologies, such as GIS, and their potential contribution to education policy planning and decision-making. A discussion on the importance of understanding the spatial relationships between the location of schools and the communities from which they draw their student populations follows. The chapter concludes with a discussion on the penetration and use of information and communication technologies (ICTs) for data sharing and dissemination, as well as the use of GIS for data analysis, and the opportunities for development of a spatially enabled education-based information management system (s-EMIS) in the context of developing countries.

Chapter 4 describes Peru in general and details the study area used for this thesis. The first part of the chapter provides an overview of the historical and current practices of planning and management of education in Peru. This is followed by an assessment of education quality at the national level relative to the international and regional contexts and at the local level in terms of the impacts of existing socio-economic and environmental factors. The context of the study area is contrasted and compared to the rest of the country through a high-level comparison between the Department of Loreto and other Departments in Peru on several selected education indicators. The second section of the chapter discusses current data collection and use within the Peruvian education system and the state of the existing data infrastructure used for education policy planning. The chapter concludes with a section on the quality and usability of the data collected and maintained by the MINEDU and the INEI at the national level in general and in the study area in particular.

Chapter 5 discusses the development and structure of an education management information system (EMIS) and the need for such a model to organise the current data holdings of the MINEDU and INEI as well as the sample data collected for the thesis. The discussion also extends to spatially enabling the standard EMIS framework using proven geodatabase concepts. A discussion on the definition and collection of absenteeism data that can be input to this model follows. This section also discusses the importance of and reasons for collecting an absenteeism indicator, and how process indicators, such as absenteeism, can be used to guide education policy planning and decision-making. Finally, techniques for analysing the spatial relationships between absenteeism and education quality including cluster analysis, spatial autocorrelation and geographically weighted regression (GWR) are discussed.

Chapter 6 discusses the data pre-processing required before statistical and spatial analyses such as analysis of the contributory factors to absenteeism and the effect of absenteeism on education quality can be carried out on the sample data and the data from the MINEDU and the INEI. The second section of the chapter presents the results of these statistical and spatial analyses performed at the student and school level. The thesis concludes in Chapter 7 with a summary of its achievements, recommendations for education policy planning, and possible areas for future research.

Chapter 2

Importance of Primary Education

This chapter discusses primary education within the broader context of the social and economic development of individuals and nations. First, the role of education in development is discussed along with a short history of the international community's efforts ultimately to achieve universal primary completion (UPC). A discussion of recent international declarations follows, focussing on Education for All (EFA), the Dakar Framework for Action (DFA) and the Fast Track Initiative (FTI). The specific targets and goals of the EFA declaration, the DFA and the FTI are then considered along with reference to the impacts these declarations have had on education systems in developing countries over the past two decades. This is followed by an examination of the meaning of the term 'quality' as it relates to education systems. A five-component model of education systems is then introduced as a basis for discussion of the nature and structure of these systems and as a framework for the evaluation of education quality at the school level. The state of primary education in both developed and developing countries is then compared and contrasted using the five-component model. Next, student absenteeism is defined and explored and its detrimental effects on education quality and student outcomes are discussed. The chapter concludes with a short exploration of the impact of morbidity on the ability of children to attend and benefit fully from school-based instruction.

2.1 Education for All

The EFA brand refers to more than just the name of the UNESCO-sponsored global movement; it stands for an egalitarian ideal at the heart of the international community's efforts ultimately to achieve universal primary completion (UPC) globally by 2015. Its meaning has become synonymous with the enhancement of education opportunities in developing countries where poor socio-economic, health and environmental conditions limit the establishment and maintenance of effective education systems. The motivation behind the EFA movement is to ensure that all children worldwide have sufficient opportunity to meet their full potential later in life and ultimately to raise the overall level of development of their respective countries. The EFA ideal also recognises that education systems cannot be separated from their socio-economic context or viewed in isolation from other social processes and institutions. In this thesis the term 'education systems' is used in a generic and all-encompassing sense in that it encapsulates indiscriminately all the processes and activities that define an education system at both highly aggregated (national) and very local (school and classroom) levels.

The international community also recognises that development occurs when systems of education, health and security work in concert for the mutual benefit of individuals and nations. Thus, any initiative intending to improve education quality at the local level must respect the relationships among these systems, especially with respect to the health and security of children. The following sections explore these issues by examining first the role of education in the development of individuals and nations. Subsequently, a brief history is presented of the international community's efforts to provide basic education for all school-aged children, culminating in the EFA declaration, the DFA and the FTI.

2.1.1 The Role of Education in Human Development

As noted previously, education plays a vital role in the process of development and the state of well-being for both individuals and nations. This is most easily demonstrated in economic terms and can be seen in the positive relationship between average annual earnings and the level of education attained using data from the United States (US) as shown in Figure 2.1. The figure demonstrates clearly that higher education attainment corresponds to increased private rates of return (e.g., personal wages). Additional non-economic benefits of higher education attainment include increased health, an improved sense of well-being, increased job satisfaction, improved environmental consciousness, and an improved sense of security (Vila, 2005). Significantly, children of highly-educated parents also benefit from improved health, increased cognitive development, and better social adaptation relative to peers with less-educated parents (Vila, 2005).

Societies also benefit from direct and indirect investment in education beyond the personal benefits accrued by individuals. The social rate of return on investment in education is defined as the benefits accrued from investment in national systems of education by society in general. For example, equality of distribution of education within a country is positively associated with economic growth and increased investment in both physical and human capital (Psacharopoulos & Patrinos, 2004); increased funding for the physical infrastructure of education, especially investment in new schools, tends to increase income equality within a country by increasing the supply of educated workers (Maoz & Moav, 1999); and, a better educated workforce corresponds directly to increases in production capacity as well as to direct increases in foreign investment in domestic labour markets (Saxton, 2000).

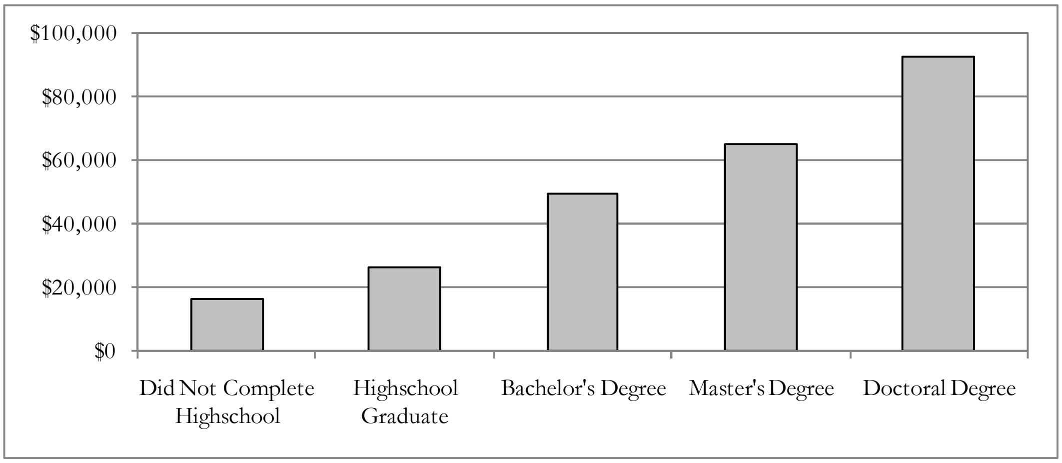


Figure 2.1 – Average annual salary among full-time labourers in the US (US Census Bureau, 2005)

Even more importantly, the increase in production capacity as a result of investment in education translates directly into the development of new technologies, processes and conceptual advances. These developments then translate directly, via a continuous feedback process, into improvements in education systems. Thus, the level of education provided at each stage of schooling develops ideally along with the advances of society (in terms of knowledge and production) in order to prepare current students for future labour market needs. In a developing and growing economy this feedback system prepares each successive cohort of students to begin where their predecessors left off (David & Lopez, 2001). This feedback process is especially important to modern information and knowledge economies which are driven by rapid advancements in science, innovation and technology (Colecchia, 2000).

In general, increased education achievement also reduces the risk of poverty, social alienation and dependency on social support systems, provided there are enough employment opportunities for each successive graduating cohort (Levin & Kelly, 1994). Increases in charitable donations, volunteerism and other altruistic behaviours which benefit local and regional communities are also related directly to increased education achievement (Dye, 1980). Education also tends to develop a stronger sense of citizenship which is demonstrated through increased voting, contributions to political activity and participation in local community organisations. This engenders public benefits, as increased citizenship leads to reinforced concepts of democratic principles, such as a reduction in political oppression and increased employment opportunities for minorities and marginalised peoples (Vila, 2005).

Finally, education translates directly into more stable communities, which are less likely to experience violent social conflicts, both internally and externally with other communities (Vila, 2005). Figure 2.2 demonstrates this by showing the difference in the adult crime rate for the fifteen States with the highest education achievement rates (defined as the percentage of population 25 years and older with at least a high school diploma) compared to the fifteen States with the lowest education achievement rates (Saxton, 2000). While this statistic does not include violent crime, such as murder or rape, the difference in crime rates between the highest and lowest percentile States on education achievement suggests that the underlying social processes or pressures that manifest as criminal behaviour are at least mitigated or reduced by increased investment in education. Investment in education systems can thus be rationalised, despite the high initial economic cost, as an exercise in self-interest and peacemaking for the benefit of all nations (Chabbott, 2003).

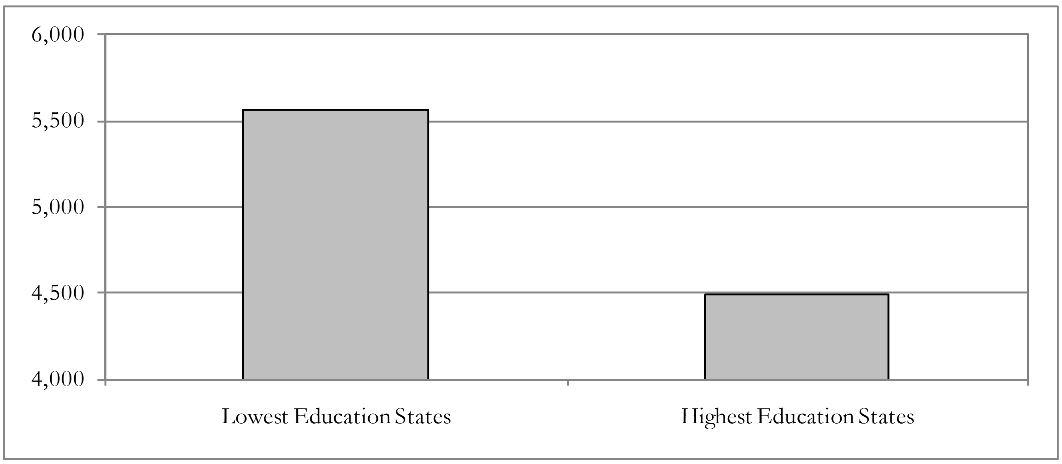


Figure 2.2 – Crimes per 100,000 people in 1996
(Adapted from Saxton, 2000)

While the focus of this thesis is on primary education, it is clear that the social returns on investment in education discussed to this point begin immediately as early as the pre-primary (kindergarten) levels of schooling and continue through to the secondary and tertiary levels of education. At the earliest stages education reinforces socially acceptable behaviours such as tolerance and sharing which is part of normal human development. These behaviours lay the groundwork for a more civilised and tolerant society and the benefits of exposure to these life lessons have been shown to accumulate with each successive level of education attained (Vila, 2005). Thus, each level of schooling, experienced continuously and completely by the student, makes an important contribution to his/her future opportunities and outcomes.

Given the situation as described above, it is not surprising that nations worldwide experienced an 18.5% social return on investment (i.e., direct economic benefits accrued by national labour markets and industry as a result of a better educated labour force) in public primary education during the 1980s. In addition, the social return on investment at the national level for secondary and tertiary levels of schooling during the same period was 14.1% and 11.8% respectively (Psacharopoulos & Patrinos, 2004). While it appears that the social return on investment decreases for each successive level of schooling, it should be noted that these figures are cumulative (i.e., these returns are in excess of the returns accrued through investment in each of the previous levels of education) (Psacharopoulos & Patrinos, 2004).

Unfortunately, the opportunity to pursue education, especially at the highest levels, is not always available, especially in the case of developing countries and the economically depressed regions of developed countries. Pursuit of higher levels of education requires a considerable investment of time and money on the part of the prospective student, even where higher education is publicly subsidised (Saxton, 2000). Prospective students are often also required to forego potential short term income in order to complete higher levels of education (David & Lopez, 2001). Figure 2.3 shows the educational attainment of individuals within a cohort of the US population (non-institutionalised civilians over the age of 14).

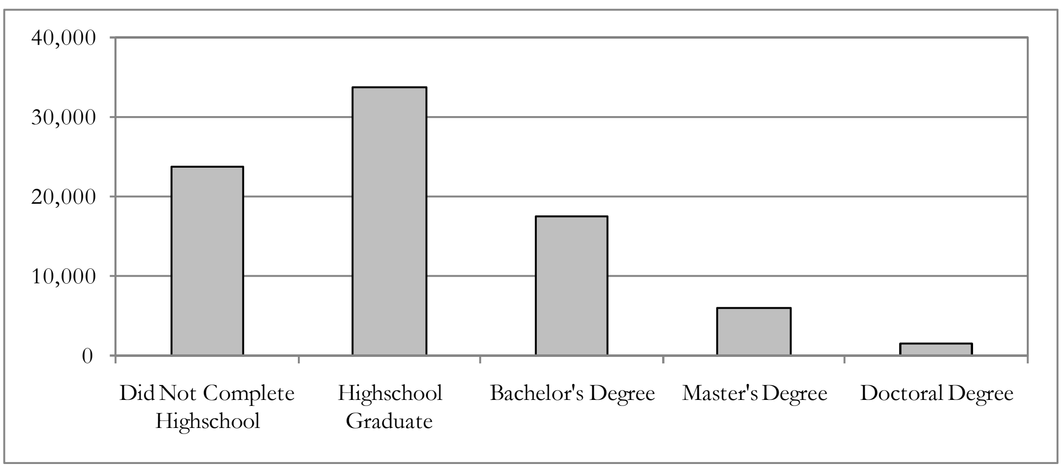


Figure 2.3 – Education attainment of US civilians over the age of 14 (1,000s)
(US Census Bureau, 2005)

As the figure shows, the majority of students either complete their education during or at the end of the secondary school cycle, with only 51% of high school graduates continuing on to earn a Bachelor's degree. While it is not possible to determine directly the reason for the declining numbers of graduates at each successive level of education, it is clear from the figure that for reasons of either ability, choice, or accessibility attaining higher levels of education is difficult or not-preferred even within education systems regarded widely as established and efficient. Clearly, the removal of these barriers, which are often much more substantial in the case of developing countries, is required for nations to experience the full benefit of their investments in their national systems of education.

2.1.2 History of International Education Development Initiatives

It is not surprising that the necessity of achieving accessible primary education has been recognised by the United Nations (UN) since its inception in 1945, given the substantial private and social returns on investment in education discussed above. The UN was founded upon the ideal of bringing all nations of the world together to work for peace and development. As such, the principles of justice, human dignity and the well-being of all people guide the UN in its policies and initiatives (United Nations, 2007b). The critical role of education in achieving the goals of the UN was first recognised in Article 26 of the Universal Declaration of Human Rights (UDHR) in 1948:

> (1) Everyone has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory. Technical and professional education shall be made generally available and higher education shall be equally accessible to all on the basis of merit;
>
> (2) Education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms. It shall promote understanding, tolerance and friendship among all nations, racial or religious groups, and shall further the activities of the United Nations for the maintenance of peace; and
>
> (3) Parents have a prior right to choose the kind of education that shall be given to their children (United Nations, 1948).

Article 26 laid the groundwork for the acknowledgement of accessible education as a driving force behind the development of individuals and nations. At this time education was considered to be accessible when children of the appropriate age for a given level of education had the means, resources and ability to attend school and benefit fully from the instruction received. Article 26, however, did not address the specific challenges that education systems faced with respect to established cultural and religious biases, nor did it offer any framework or guidelines for the achievement of these ideals. The Article also made no mention of the importance of continuous and uninterrupted access to differing levels of education, (such as primary, secondary, and tertiary education) which is critical to student advancement through education systems.

These and other education-specific shortcomings of the UDHR were taken into account during a series of education development conferences held during the 1960s. The Addis Plan (1960), produced by Ministers of Education in the equatorial region of Africa, is recognised to be the most important outcome of these conferences. This Plan proposed strategic human and resource development aimed at improving secondary and post-secondary education while still upholding the ideal of increasing accessibility to primary education. The Plan was a results-focussed action plan based on the demonstrated needs of the participating countries and expressed in terms of their financial and material requirements. The Addis Plan also made a case for the positive impact of education on the economies of the participating counties, and the region as a whole (Bertrand, 2003). The plan was divided into independent short-term and long-term phases that were designed to meet the perceived and recognised needs of the time.

The Short-Term Plan (1961-1966) focussed on secondary education, curriculum reform and teacher training. The goal of this plan was to increase total school enrolment from 11 to 15 million students during the half decade (Bertrand, 2003). The Long-Term Plan (1961-1980) aimed specifically at delivering primary education of high quality by 1980. Important features of the Long-Term Plan were ownership of education systems by each participating country, concern for quality, and the recognition that improving primary education systems requires a significant investment in the school system and school resources, especially the need for highly trained educators (Bertrand, 2003). Despite the optimism behind and support for the Addis Plan, it was never fully implemented or adopted by the participating nations (Bertrand, 2003). Research at the time revealed significant gaps between the widely supported goals of the Plan and the financing necessary to realise these goals (Chabbott, 2003).

In 1966 the UN adopted the International Covenant on Economic, Social and Cultural Rights (the Covenant) which built upon the UDHR and the lessons learned during the partial implementation of the Addis Plan. Article 13 of the Covenant refined the ideals laid out in Article 26 of the UDHR to include a stronger sense of respect for the individual (including gender equality) and an expanded view of the rights of parents, including access to education which conforms to the moral and religious convictions of the family (United Nations, 1966). In addition, Article 13 also introduced the concept of minimum standards (albeit in a limited sense) for private and non-state controlled education systems. This makes the Covenant the first UN-sponsored document to include the understanding that access to education must be accompanied by a set of minimum standards for the delivery of that education (i.e., the concept of quality as it relates to education). Article 13 paragraph 3 states:

> (3) The States Parties to the present Covenant undertake to have respect for the liberty of parents and, when applicable, legal guardians to choose for their children schools, other than those established by the public authorities, which conform to such minimum educational standards as may be laid down or approved by the State and to ensure the

> religious and moral education of their children in conformity with their own convictions (United Nations, 1966).

Article 14 of the Covenant notes the relative importance of primary education in the overall education cycle and also notes that education can only be considered accessible when it is affordable to the majority of the population. In Article 14 this dimension of accessibility is attributed, to varying degrees, to all levels of schooling including primary, secondary and tertiary education. Whereas primary education was to be made available free to all immediately, the Article allowed for the progressive, long-term, introduction of free secondary and tertiary education. Article 14 states:

> (14) Each State Party to the present Covenant which, at the time of becoming a Party, has not been able to secure in its metropolitan territory or other territories under its jurisdiction compulsory primary education, free of charge, undertakes, within two years, to work out and adopt a detailed plan of action for the progressive implementation, within a reasonable number of years, to be fixed in the plan, of the principle of compulsory education free of charge for all (United Nations, 1966).

The ideals upheld by the UDHR and the Covenant set the standard for contemporary education systems in Western societies and framed the global discourse on how education systems should function in all contexts, whether developed or developing. These education systems are based on democratic ideals and the egalitarian concept of education as a basic human right that must be accessible to the entire population, regardless of gender, race or religion. The UDHR and the Covenant also set the stage for all future declarations and international education improvement efforts by recognising the role of education as the primary vehicle by which economically and socially marginalised people can lift themselves out of poverty and obtain the means to participate fully in their communities and nations (United Nations, 1948).

During the 1970s international education discourse focussed on the concept of basic human needs and poverty reduction. This discourse arose in part due to the failure of the UDHR and the Covenant to generate any substantial improvement in education systems outside of the highly developed Western countries which had the luxury of injecting large sums of money to their education systems, due to their relative prosperity and security. There was also recognition of the relative and recent failures of imposing formal Western education ideals and processes enshrined in the UDHR and the Covenant on largely informal, community-based education systems in developing countries (Chabbott, 2003). This lead to the UN's adoption of the basic human needs approach (circa 1976) which focussed on strategies for solving global socio-economic problems that affect the dignity and rights of the individual, based on the actual needs and realities of these peoples rather than a Western-centric international template (Jordan, 1976).

The concept of 'basic education' was introduced at this time. This concept referred to practical forms of education that specifically addressed survival needs, with a focus on ensuring access to education for those who needed it the most. Criticisms of basic education were based on the suggestion that it justified the provision of little more than the minimum with respect to education quality, and did not specifically create opportunities for advancement onto higher levels of education (Chabbott, 2003). Central to the issue was the inadequacy of the domestic budgets of developing countries to provide the same education opportunities to their citizens as those of developed countries. The solution, although never fully implemented, appeared to be a partnering of developing countries with donor countries (a solution which was revisited in 2004 by the FTI). This solution required a reiteration of the obligation of UN member nations to uphold education as a fundamental human right, as well as establishing the link between education and other fundamental human rights such as health and security (Jordan, 1976).

Other international agencies, such as the International Labour Organisation (ILO) and the International Symposium for Literacy (ISL) contributed to the discourse during this period by passing resolutions which strengthened the role of education as a fundamental human right. The ILO Minimum Age Convention (C138), which came into force in 1976, set the minimum age for participation in the formal economy and labour market (International Labour Organization, 1973). Article 2, Paragraph 3 states:

> (3) The minimum age … shall not be less than the age of completion of compulsory schooling and, in any case, shall not be less than 15 years (International Labour Organization, 1973).

Convention 138 also set out standards for the type of work that could be performed by youths. Article 7, Paragraph 1 allowed youths aged 13 to 15 to engage in light work, provided that the work was:

> (a) Not likely to be harmful to their health or development; and
>
> (b) Not such as to prejudice their attendance at school, their participation in vocational orientation or training programmes approved by the competent authority or their capacity to benefit from the instruction received (International Labour Organization, 1973).

The ISL adopted the Declaration of Persepolis (1975) which characterised literacy as vital for basic survival and a requirement for people to participate freely in society (International Labour Organization, 1973). The combined effect of these standards was an attempt to limit externalities from influencing a child's ability or opportunity to attend school continuously throughout her/his childhood. A final externality, childhood health, was addressed in 1978 by the World Health Organization (WHO) and the

United Nations Children's' Fund (UNICEF) at the Health for All (HFA) Conference. Here, the delegates affirmed that health, defined as a state of complete mental, physical and social well-being and not merely the absence of disease is a basic human right for all people, especially children. While the HFA declaration did not explicitly make a link between education and health, it laid the groundwork for establishing this link in later research by recognising that health forms an integral part of the overall social and economic development of the community (Pan American Health Organization, 1978).

The 1980s, on the other hand, was a period of relative stagnation in international development and discourse. The focus during this period shifted to effective management of education resources due to the advent of the debt crisis in the early 1980s, which occurred due to a worldwide collapse in the export price of commodities from developing countries (e.g., coffee, and cocoa), rising oil prices, and rising interest rates (Federici, 2001). This lead to the imposition of massive debt restructuring by the World Bank (WB) and the International Monetary Fund (IMF) (The Disinvestment Campaign, 2007). The debt restructuring prescribed, among other things, programs which rewarded governments and institutions for decentralisation and increased dependence on local communities (Federici, 2001).

The goal of the restructuring was to reduce the costs required to support large, centralised ministries, especially in the areas of special services such as education and health. Measures were also put in place for improved education data collection for measuring student performance and the impacts of reformed education planning and policy (The Disinvestment Campaign, 2007). These measures were backed by UNESCO as they promoted development of education systems and curricula that were aimed at meeting the local needs of, and improving the opportunities for, impoverished communities, even though the measures often did not contain adequate secured funding to support the devolution of responsibilities.

Education planning and policy can refer to multiple different aspects of education systems. In some cases the term is used to refer specifically to pedagogical standards and curricula design. In others the term is used to refer to budgeting and financial issues. In still other cases the term is used to refer to facility management (schools) and resource allocations (teachers, books and teaching materials). In addition, the actual activities and processes of education planning, irrespective of the definition used, are different at each level of the education system. For example education resource planning at the national level is concerned with the proper placement of teachers to meet demand, whereas at the local level education resource planning includes the allocation of books to individual students, or chalk and other often used supplies to classrooms. In this thesis the term education planning is used liberally, and encompasses all aspects of education planning with respect to this discussion.

The 1990s saw a resurgence in international development initiatives, most notably the creation of the Human Development Index (HDI) and the World Conference on Education for All (WCEFA). The HDI marked the first truly global attempt to compare all countries on a single index of development by quantifying the role of development of human capital for the benefit of nations (Chabbott, 2003). The HDI is calculated by an unweighted average of the following three general indices:

(1) Health and well-being (measured by life expectancy);

(2) Education (measured by adult literacy and gross enrolment ratio); and

(3) Standard of living (measured by purchasing power parity, and income) (UNDP, 2006).

Calculating the HDI in this way is evidence of the acknowledgement of a direct link between health and education, as well as an understanding that both health and access to education contribute equally to the development of society. The goal of the HDI was to provide a broadened 'prism' for viewing human progress and to provide a basis for comparison between countries (UNDP, 2006). Since the purpose of the HDI was to produce an index that included all countries, it needed to focus on data which were readily available from all nations, and which were easily expressible in quantifiable terms. Thus, the HDI was not truly a measure of standard of living or quality of life as important qualitative measures of human development such as respect for human rights, principle of open and democratic society and social inequality were not included in the index (UNDP, 2006). Despite its limitations, the HDI is a widely accepted benchmark and is still used as an important indicator by the international development community to gauge the development and progress of individual nations (UNDP, 2006).

At the same time that the HDI was gaining acceptance as a yardstick for national development the Education for All (EFA) declaration was authored by the WCEFA delegates. The WCEFA was a global initiative on behalf of the international community with the stated goal of achieving basic primary education for all by the end of the 20th century (UNESCO, 1990). To make the conference as inclusive as possible, it concluded with the issuance of a non-binding declaration, rather than a formal charter which would have carried legal ramifications for non-compliance or failure to meet the stated goals. This created a more open and informal atmosphere and allowed development agencies, non-governmental organisations (NGOs), and government officials responsible for economic planning to attend and contribute (Chabbott, 2003).

The goals of the WCEFA were to re-establish the legitimacy of education as a core international development issue and to mobilise resources to allow developing nations to adopt and implement plans for improving their education systems. In order to accomplish this, the conference had to establish a consensus among all participants on a framework for action capable of addressing basic learning needs (Chabbott, 2003). At the time of the conference, stagnation and/or deterioration of education in developing countries since the 1970s had lead to a global crisis of education. Most notable among these, according to the delegates at the WCEFA were:

(1) More than 100 million children, including at least 60 million girls, have no access to primary schooling; and

(2) More than 960 million adults, two-thirds of whom are women, are illiterate, and functional illiteracy is a significant problem in all countries, industrialized and developing (UNESCO, 1990).

During this period mounting debt burdens, the threat of economic stagnation and decline, rapid population growth, widening economic disparities among and within nations, war, occupation, civil strife, violent crime, the preventable deaths of millions of children, and widespread environmental degradation posed serious challenges to meeting the basic learning needs of children and adults alike (UNESCO, 1990). These problems resulted in major setbacks in basic education funding and maintenance of education facilities and resources, especially in many of the least developed countries. In addition, developing countries which experienced moderate economic growth during this period did not necessarily increase or maintain spending on education, and many millions remained in poverty, unschooled, and illiterate. Even in developed countries, cutbacks in government expenditure over the 1980s led to the broad deterioration of education systems (UNESCO, 1990). Thus, the WCEFA participants acknowledged that the provision of education at the time was seriously deficient and that to affect any real change meant making education more relevant, especially at the community level, and making basic primary education truly available to all (UNESCO, 1990).

Thus, the participants of the WCEFA resolved to bring together all the individual and ongoing efforts towards the advancement and development of education systems under one global initiative. In this way it was hoped that the maximum benefit could be obtained from the expenditures of time, effort and money from donor countries. The EFA declaration began with several strong and clear statements which summarised the gains in knowledge from previous initiatives, specifically:

(1) Recalling that education is a fundamental right for all people, women and men, of all ages, throughout our world;

(2) Understanding that education can help ensure a safer, healthier, more prosperous and environmentally sound world, while simultaneously contributing to social, economic, and cultural progress, tolerance, and international cooperation;

(3) Knowing that education is an indispensable key to, though not a sufficient condition for, personal and social improvement; and

(4) Recognizing that sound basic education is fundamental to the strengthening of higher levels of education and of scientific and technological literacy and capacity and thus to self-reliant development (UNESCO, 1990).

This perspective elevated education from a desired goal to a central element in the process of human and national development. EFA signatories were required to serve the basic learning needs of all and to secure a recommitment to the need for basic education. The WCEFA participants drafted a vision statement that respected the best education practices of the time while calling for increased investment in resource levels, institutional structures, curricula and education delivery systems. The vision statement noted the following key goals:

(1) Universalizing access and promoting equity;

(2) Focussing on learning;

(3) Broadening the means and scope of basic education;

(4) Enhancing the environment for learning; and

(5) Strengthening partnerships (UNESCO, 1990).

While general in nature, these goals addressed clearly the interdependent domains which produce systems of education capable of meeting the goals of the EFA movement. Universal access and promotion of equity referred to the reduction of disparities in the provision of education, especially for girls, women, the poor and otherwise disadvantaged or marginalised social groups. Universal access meant that children, youth and adults all had the opportunity to achieve and maintain an acceptable level of learning. The second goal, focussing on learning, recognised that expanded educational opportunities must be translated into meaningful development for individuals and countries. In this context, learning referred to the incorporation of useful knowledge, reasoning ability, skills and values into daily life. Broadening the means and scope of basic education referred to an understanding of the role education plays in development, especially in the early stages of life.

Learning, as defined by EFA and future declarations, begins at birth and is reinforced by a stable home environment and continuous access to primary schooling (UNESCO, 1990). The goal of learning also took into account the basic learning needs of all children and included respect for the culture, needs and opportunities of specific communities. Enhancing the environment for learning recognised that learning does not take place in isolation. Nutrition, health care and general physical and emotional support during primary schooling (and at all levels) are critical to ensure that children participate actively in and benefit from their education.

The final goal, strengthening partnerships, recognised that the obligation to provide basic education lay at the national, regional and local levels. However, government ministries in developing countries could not always be called upon, due to a lack of resources and capacity, to provide all the inputs required to achieve basic education. Thus, the EFA declaration called for partnerships among administrators and other education personnel, government departments, planning, finance, labour, communications, and other social sectors, government and NGOs, the private sector, local communities, teachers, religious groups and families. Only through partnerships among all these various stakeholders could EFA realistically be achieved. Thus, the EFA declaration concluded with three requirements placed upon participants in order to achieve its goals:

(1) Developing a supportive policy context;

(2) Mobilizing resources; and

(3) Strengthening international solidarity (UNESCO, 1990).

The first requirement referred specifically to the need for a commitment from the social, cultural and economic sectors to achieve the goals of EFA. The achievement of EFA also depended upon political commitment and will, backed by appropriate fiscal measures and reinforced by educational policy reforms and institutional strengthening. Mobilising resources referred to the need for expanded financial, human, public, private and voluntary resources in order to support a much broader scope of action. This requirement acknowledged that all of society had a contribution to make to basic education. Strengthening international solidarity meant acceptance of a common and universal human responsibility towards education and development. It acknowledged the need for equitable and fair economic relations in order to redress existing economic disparities which continue to exist today.

The EFA declaration was accompanied by a framework for action which targeted the responsibilities and obligations of WCEFA participants. The main goal of the framework was to implement time-bound targets in order to convey a sense of urgency and to serve as a reference against which indices of implementation and accomplishment could be measured. The framework outlined responsibilities at the national, super-national regional and global levels. At the national level, responsibilities included:

(1) Assessing needs and planning action;

(2) Developing a supportive policy environment;

(3) Designing policies to improve basic education;

(4) Improving managerial, analytical and technological capacities;

(5) Mobilizing information and communication channels; and

(6) Building partnerships and mobilizing resources (UNESCO, 1990).

These responsibilities supported the goals of the EFA vision and the requirements placed on participants by outlining the actions that national governments needed to take to support the provision of basic education for all. It was also clear that full execution of these responsibilities required learning on the part of governments and their ministries. Because of this, the responsibilities set out at the regional and global levels were designed to share knowledge, information and capacity efficiently to help individual countries meet their goals and responsibilities. The framework required countries to set specific targets to complete or update their plans of action to meet basic learning needs, with support from donor countries. In addition, the framework called for continued advocacy of the principals of EFA at the global and super-national regional levels as well as building institutional and popular support for improved education systems in developing countries.

The motivation behind the framework was to give teeth to the non-binding EFA declaration. Signatories to the EFA declaration and the framework agreed to take follow-up steps as recommended in the framework and to report progress to monitoring cells set up by the Forum for Education for All Secretariat beginning in 1991. The sponsors of the EFA process hoped that the framework would serve as a transitional document that could eventually become the basis of a formal and binding convention. The EFA companion framework concluded with a stirring call to action:

> There will never be a better time to renew commitment to the inevitable and long-term effort to meet the basic learning needs of all children, youth and adults. This effort will require a much greater and wiser investment of resources in basic education and training than ever before, but benefits will begin accruing immediately and will extend well into the future – where the global challenges of today will be met, in good measure, by the world community's commitment and perseverance in attaining its goal of education for all (UNESCO, 1990).

As of 2007 the highest ambitions of the EFA movement have yet to be realised. However, many of the principles of the companion framework were incorporated into the Convention on the Rights of the Child (CRC) thus giving them international legal status (Chabbott, 2003). The CRC, which came into force in 1990, gave countries two years to develop plans to meet their goals for compliance with the convention, including access to education for all cohorts of society, especially children. Failure to meet these stated goals was to be judged as a human rights violation by the UN, with the possibility of sanctions imposed by the international community (United Nations, 1989). Article 24(e) of the CRC states:

> (e) To ensure that all segments of society, in particular parents and children, are informed, have access to education and are supported in the use of basic knowledge of child health and nutrition, the advantages of breastfeeding, hygiene and environmental sanitation and the prevention of accidents (United Nations, 1989).

However, despite the best intentions of the international development community, the EFA participants were not able to achieve their goals by the year 2000. Early optimism concerning increased enrolment rates and reductions in adult literacy was overshadowed by the overwhelming inability of the world's poorest countries to meet EFA targets (UNICEF, 1994). On the positive side, the number of children enroled in school rose by 82 million from 1990 to 1998 and many countries approached full primary school enrolment for the first time. On the other hand, 113 million children were still out of school and discrimination against girls had not lessened in many nations (UNESCO, 1996). In addition, findings from EFA monitoring and data collection throughout the decade suggested that the increase in enrolment could be attributed to education systems trying to keep pace with rapidly expanding populations (UNESCO, 2000a).

Economic barriers to the achievement of EFA also had not been overcome by the end of the 20th century. Donor countries were criticised for dwindling aid commitment, while developing countries such as Bangladesh, Brazil and Egypt were investing only six per cent of their gross national product in education (UNESCO, 2000a). On the other hand, for some African countries, education was absorbing up to a third of the national budget, even though these same countries were crippled by debt repayments that ate up more than their contribution to health and basic education combined (UNESCO, 1996). Disparities in quality were also widespread as education systems were unable to keep pace with rapid technological and scientific advances, and had lost touch with the needs of young people (UNESCO, 1996).

In 2000 the EFA was revisited by the international development community at the World Education Forum in Dakar, Senegal. This conference resulted in the Dakar Framework for Action (DFA), which expanded upon and enhanced the original EFA declaration. Most important on the agenda at this conference was the increasing disparity in the delivery of education both within and between countries at the time. Overall, per capita spending in most of the developing world had declined throughout the 1990s, mostly due to rapid population growth, which increased the economic burden on the working cohort (aged 15-64) to fund the education of the burgeoning student cohort (aged 0-14) (UNESCO, 2000a). The DFA set out to define a new language and a new discourse, updating the contested terminology of basic primary education to the more inclusive concept of universal primary education (UPE). In order to achieve UPE, the DFA set out six new and expanded goals:

(1) Expanding and improving comprehensive early childhood care and education, especially for the most vulnerable and disadvantaged children;

(2) Ensuring that by 2015 all children, particularly girls, children in difficult circumstances and those belonging to ethnic minorities, have access to and complete, free and compulsory primary education of good quality;

(3) Ensuring that the learning needs of all young people and adults are met through equitable access to appropriate earning and life-skills programmes;

(4) Achieving a 50 per cent improvement in levels of adult literacy by 2015, especially for women, and equitable access to basic and continuing education for all adults;

(5) Eliminating gender disparities in primary and secondary education by 2005, and achieving gender equality in education by 2015, with a focus on ensuring girls' full and equal access to and achievement in basic education of good quality; and

(6) Improving all aspects of the quality of education and ensuring excellence of all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills (UNESCO, 2000b).

These new goals extended the original WCEFA goals by including specific reference to the concept and need for a quality education as well as extending the deadline for achieving UPE to a more realistic target of 2015. The impetus for a stronger focus on quality (goal six) was born of the realisation that EFA had engendered a classic race to the bottom (a phenomenon which occurs when competition between political or administrative entities, in this case for aid money, leads to the progressive dismantling of regulatory standards in order to achieve quickly desirable and measurable results) whereby quality and relevance of education was sacrificed in order to achieve numerical superiority in primary school admissions.

What is clear is that quality should not suffer as access expands and that improvements in quality should not benefit the economically well-off at the expense of the poor, although this seemed to be the case with respect to the implementation of the recommendations of the EFA declaration (UNESCO, 2000b). In order to achieve the goals set out in the DFA, twelve new strategies (largely based on the EFA strategies) were introduced:

(1) Mobilize strong national and international political commitment for education for all, develop national action plans and enhance significantly investment in basic education;

(2) Promote EFA policies within a sustainable and well integrated sector framework clearly linked to poverty elimination and development strategies;

(3) Ensure the engagement and participation of civil society in the formulation, implementation and monitoring of strategies for educational development;

(4) Develop responsive, participatory and accountable systems of educational governance and management;

(5) Meet the needs of education systems affected by conflict, natural calamities and instability and conduct educational programmes in ways that promote mutual understanding, peace and tolerance, and that help to prevent violence and conflict;

(6) Implement integrated strategies for gender equality in education which recognize the need for changes in attitudes, values and practices;

(7) Implement as a matter of urgency education programmes and actions to combat the HIV/AIDS pandemic;

(8) Create safe, healthy, inclusive and equitably resourced educational environments conducive to excellence in learning, with clearly defined levels of achievement for all;

(9) Enhance the status, morale and professionalism of teachers;

(10) Harness new information and communication technologies to help achieve EFA goals;

(11) Systematically monitor progress towards EFA goals and strategies at the national, regional and international levels; and

(12) Build on existing mechanism (UNESCO, 2000b).

These strategies stated the expanded goals of the DFA more succinctly and also made specific reference both regionally (strategy 7) and globally (strategy 8) to the contribution of health to education opportunities, especially for children. In addition to recognising the effect of health on education, these strategies effectively linked education directly or indirectly to other areas of development including economics, human rights, gender equity, health and governance. Additionally, while not stated explicitly as a strategy, the DFA acknowledged that health problems prevented children from attending school and from learning. Ensuring that children are healthy and able to learn was (and still is) especially relevant to efforts to increase learning achievement because it encouraged the poorest and most disadvantaged children to attend school and to devote the needed efforts for success (UNESCO, 2000b).

As the revised deadline of 2015 approaches, there is a growing sense of urgency in the international community. This urgency is reflected by the commitment of all the world's countries and leading development agencies to renew the goals, targets and frameworks for action encompassed by the EFA and the DFA. This commitment, especially with respect to providing UPE was reiterated in the United Nations Millennium Declaration (UNMD) of 2000. While not a part of the EFA process, the UNMD provides a blueprint upon which all international development declarations can build and complements the goals of the EFA and the DFA. The UNMD set out eight specific goals which the international community felt were critical to the development and prosperity of the world's poorest nations. These eight Millennium Development Goals (MDGs) are to:

(1) Eradicate extreme poverty and hunger;

(2) Achieve universal primary education;

(3) Promote gender equality and empower women;

(4) Reduce child mortality;

(5) Improve maternal health;

(6) Combat HIV/AIDS, malaria, and other diseases;

(7) Ensure environmental sustainability; and

(8) Develop a global partnership for development (United Nations, 2000).

These goals represent an understanding that health and security work in concert with education to provide the cornerstone upon which an individual's highest potential can be reached. Significantly these goals focus on childhood as this is the most critical period of development. They also acknowledge the critical linkages between health, education and security, especially with respect to children. This places primary education and childhood health at the centre of all development goals and allows children sufficient opportunity to meet their full potential later in life and ultimately to improve the overall level of socio-economic development of their respective countries.

Two years after the DFA, the enormity of the UPE challenge was again readdressed by the international community. The need for more effective partnerships and coordinated efforts between all the partners had become abundantly clear. Ensuring continued international support to recipient countries and maximising the benefits of that support through effective co-ordination were considered to be vital and urgent for substantive progress to be made in achieving the core EFA goals (UNESCO, 2002). Thus, building on the momentum provided by the MDGs and the relative successes of the EFA and the DFA, the Fast Track Initiative (FTI) was introduced in 2002 as a supplemental partnership strategy for the achievement of the EFA movement's declared goals by 2015. The FTI also introduced the concept of universal primary completion (UPC) which acknowledged that benefits accrue not only from access to quality education but also from continued attendance and timely progression through the education system.

The FTI draws upon the tenets of the development consensus reached at Monterrey in 2002, which called for increased and sustained long term funding through partnerships between donor and recipient countries. The value of strategic donor/recipient partnerships had long been understood, yet prior to the Monterrey consensus the political will to implement such partnerships had not existed. The FTI is the most recent product of the EFA lineage, and is currently the guiding framework for international education efforts. The FTI explicitly links increased donor support for primary education to the education policies of developing countries, and requires performance monitoring and increased accountability of results. The specific goals of the FTI are:

(1) More efficient aid for primary education;

(2) Sustained increases in aid for primary education;

(3) Sound sector policies in education;

(4) Adequate and sustainable domestic financing for education; and

(5) Increased accountability for sector results (UNESCO, 2002).

These goals take advantage of the recognition in the Monterrey Consensus that education is part of the basic economic and social infrastructure for sustainable development, and that increased external aid is the only way for some of the poorest countries to build capacity in basic education and other social domains. The FTI was introduced to ensure that these new aid commitments translate into significant new resource inputs and outcomes towards achieving UPC. The FTI also provides a concrete framework for linking donor funding directly to performance, as well as minimising transaction costs to donor countries, so as to maximise the amount of funding actually reaching the education systems in developing countries (World Bank, 2004b). With the FTI, continued and increased funding is contingent on the recipient country meeting certain milestones, which are mutually agreed upon by the donor and recipient countries, thus increasing the accountability for both. The FTI also set out a framework which both donor and recipient countries must follow:

(1) A single, credible education sector plan for achieving agreed education outcomes;

(2) A common set of measurable benchmarks used to track progress;

(3) Donor commitment to harmonize financing, implementation and monitoring activities; and

(4) Donor commitment to predictable, long-term financing for the agreed sector plan, and country commitment to ensure political and financial support for implementation (UNESCO, 2002).

The FTI also called for strengthening the statistical capacity and evaluation methodologies used in developing countries and for the development of education management information systems (EMIS). These systems promote results-based management and support evaluation of progress towards UPC measured against a set of internationally recognised indicators. Fully implemented EMIS cover all information needs of education planners and decision-makers, enable data collection, storage and processing and also assist in the formulation of education policies as well as their management and evaluation (UNESCO, 2006). The ability to collect appropriate data to populate EMIS and the capacity to analyse the data collected in order to influence policy and affect change is regarded as critical to the success of these systems. However, even where data collection regimes are well established, policymakers rarely use the information provided by EMIS to guide education policies, due to lack of capacity, resources and/or understanding of the inherent value of these data (UNESCO, 2006).

The dissemination of the contents of EMIS from central ministries and statistical agencies to regional and local level stakeholders is dependent on information and communications technologies (ICTs). These technologies play an important role in improving general public awareness of important social issues and in the collection and maintenance of information relevant to systems of education and health. While governments and NGOs at national and sub-national levels in developing countries generally have at least basic ICT infrastructure, they often lack the resources (e.g., time, money, and capacity) to exploit the full potential of these technologies (International Monetary Fund, 2006). Thus, while the EFA declaration and the DFA acknowledged the rapid penetration of ICTs and called for an investment in these technologies they were unable to affect any real change due to lack of resources on the part of most developing nations. The FTI, however, which reiterates the importance of capacity building in ICTs and the need for fully-developed EMIS in order to evaluate progress, also includes a funding strategy for capacity building to ensure that these systems are built (World Bank, 2004b).

More relevant to this thesis is the increasing capacity for the use and analysis of geographic and information technologies, such as Internet-based mapping tools and location-based services. This has fostered tremendous growth in the importance and use of geographic information systems (GIS) for participation in decision-making and planning (Hall & Leahy, 2006). Researchers and policymakers have begun to embrace the spatial component of knowledge and applied GIS to model health, education and other social systems to determine the effect of geographic and localised contextual and environmental factors on these systems.

While this is more prevalent in developed countries, the importance has also been recognised in some parts of the developing world due to the efforts of academic institutions and international aid organisations. Thus, the inclusion of EMIS in the FTI creates the necessary momentum and funding to include powerful and advanced geographic analysis of education-based indicators in the evaluation of education systems. For example, applied research has found that health problems, such as tropical diseases and chronic illnesses, have a geographical dimension, and analysis of the spatial relationships between the location of student's homes and schools can reveal problem clusters and aid in the development of policies and strategies to reduce the burden of many health problems for children (Martin, Curtis, Fraser, & Sharp, 2002).

2.2 Education Quality

Systematic measurement and monitoring of progress towards UPC is critical to ensure its achievement. In addition, ongoing monitoring of education systems is necessary to determine how interventions and policy affect their planning, management and outcomes (Graeff-Martins et al., 2006). These monitoring efforts involve (i) determining how well existing education systems are functioning, (ii) identifying both geographic and thematic areas in need of change or assistance, (iii) developing plans of action for improvement and (iv) measuring the impacts of structural change, resource allocation and reallocation and school or community interventions on education systems. This assumes, however, that there is a clear definition of desired outputs and outcomes of education, and a clear methodology by which progress towards achieving these outputs and outcomes can be measured (Graeff-Martins et al., 2006).

The original EFA provided a statistical companion document that listed a series of 18 critical indicators by which to measure the achievement of EFA goals (UNESCO, 2000a). The indicators were divided into five categories and focussed largely on financial and resource inputs to education systems. Only one of the indicators, namely literacy, measured the eventual outcomes of education processes. These 18 indicators have since become the de facto standard for analysis and comparison of education systems with respect to the achievement of UPC in developing countries.

Indicators such as gross enrolment ratio (GER), net enrolment ratio (NER), apparent intake rate (AIR), as well as measures of public expenditure on education as a percentage of gross national product (GNP) now are collected annually and considered authoritative measures of the progress of education systems towards the goal of UPC (UNESCO, 2000, World Bank, 2004, UNESCO 2005). In recent years additional indicators such as the rate of grade repetition which measures the internal efficiency of education systems as well as outcomes have been introduced. These indicators are thought to be more appropriate for measuring the quality of education delivered at the school and student level.

The following sections provide an in-depth discussion on various aspects of education quality as well as methodologies for the measurement and monitoring of progress towards the goal of UPC. This discussion also outlines the relationship between education and the socio-economic and environmental contexts in which education services are delivered. Following this, the state of education in developing countries is discussed in relation to the goals of the EFA movement as described above.

2.2.1 Education Quality Defined

The concept of quality is a critical aspect of both education and development. However, major international agreements, such as those discussed earlier have generally not stipulated how education systems can and should be expected to perform in meeting the objectives of UPC. This situation remained true until as recently as 2000, when the UNMD called for the achievement of basic education for all (e.g., EFA) by 2015 without explicit reference to the quality of education delivered, nor reference to the continuous nature of the schooling process (UNESCO, 2006). Thus, in placing the emphasis upon assuring access to education, international agreements such as the UNMD and the DFA mainly reduced the concept of UPC to an enrolment-based numbers game. This is demonstrated clearly by the case of Indonesia, where the policy focus shifted to issues of education quality only after UPC had been first achieved, as required by donor nations (Suryadarma, Suryahadi, Sumarto & Rogers, 2006).

There is, at the international level, and to some extent at the national level, a lack of understanding of the social processes which affect national education systems. It is often acknowledged that improvements in resources, facilities, technology and the quality of student and teaching inputs should in principle be able to enhance the overall quality of education. Traditionally this means an increase in spending on education at the national and sub-national levels and indeed one of the key aspects of the EFA declaration, the DFA and the FTI is the increased allocation of funds to education systems. To a certain extent this relationship holds true, however, in developed countries relatively large increases in average real expenditure per student and other measures of school resources in primary and secondary schools over the last few decades have not been matched by a comparable increase in standardised test scores.

Test scores in mathematics and science have actually decreased as spending on education increased in Western countries. This effect is demonstrated most dramatically by the case of France, where a 211.6% increase in real education spending from 1970-1994 was accompanied by a 6.6% drop in mathematics scores on standardised tests (UNESCO, 2005b). Thus, it would seem that the positive effects of increased funding, critical to the establishment and expansion of education systems in developing countries, diminishes over time as more complex and difficult-to-measure social processes exert increasing influence on learning outcomes (UNESCO, 2005c).

Thus, an understanding of what comprises a quality education is critical to improving education systems in order to maximise return on investment over time. For example, how well students are taught and how much they actually learn as measured by life skill acquisition and increases in cognitive ability, creativity, and emotional maturity can have a crucial impact on how long they stay in school and how regularly they attend. Furthermore, whether parents send their children to school at all is likely to depend on judgments they make about the quality of teaching and learning provided. Families must decide whether attending school is worth the time and cost for their children and for themselves, especially in the case of developing countries where family incomes are often supplemented by child and youth labour (Ray & Lancaster, 2003). However, as previously noted, education helps children develop creatively and emotionally and acquire the skills, knowledge, values and attitudes necessary for responsible citizenship. Clearly, how well education achieves these qualitative outcomes, and how education systems are perceived as result of these outcomes, is the most important measure of the quality of the education received (UNESCO, 2005c).

Accordingly, the EFA declaration, the DFA and the FTI all have attempted to incorporate recognition of the quality of education to some degree and have over time successively strengthened the focus on quality as a prime determinant in the achievement of UPC. The sixth goal of the DFA in particular includes a commitment to improve all aspects of education quality so that all individuals can achieve better learning outcomes especially with respect to literacy, numeracy and essential life skills (UNESCO, 2005c). However, as noted previously, the quality of education delivered is too often a secondary consideration to the quantity of children who participate in schooling. While merely filling schools with children may address the commitments of international aid recipient countries, it does not address the real objectives of the education system, or adequately emphasize the real value education systems provide to individuals and nations (UNESCO, 2005c).

While the focus of the FTI is primarily on the achievement of UPC, there is also the notion that beyond the opportunity simply to attend school, there should be some minimum standard of instruction, facilities and resources provided at the school (World Bank, 2004b). This was first mentioned in the DFA and then reaffirmed specifically in the FTI where it was noted that primary education should be free, compulsory and of 'good quality' (World Bank, 2004, UNESCO 2000). However, neither the DFA nor the FTI provide a clear definition of what constitutes 'good quality' and neither presents a comprehensive method for effective measurement and monitoring of the change in education quality over time.

While the DFA and the FTI both advocate standardised testing as a partial measure of quality, testing cannot entirely account for the effects that a particular teacher, school or policy have on student performance. Indeed, factors such as background, socio-economic conditions, differential access to facilities and inherent ability often explain much of the variance in student performance (Suryadarma, Suryahadi, Sumarto & Rogers, 2006). Testing is more an indicator of student performance, which does not necessarily directly relate to education quality. Strong performance may simply reflect the student's innate ability or prior preparation, rather than the contribution of the school or education system (Suryadarma, Suryahadi, Sumarto & Rogers, 2006).

Thus, a growing consensus over the need to provide access to education of good quality does not translate to an agreement about what the term actually means in practice. One of UNESCO's first position statements on quality in education stated that the aim and content of education are in need of rethinking, and should include the new features of society and democracy with a focus on recent scientific and technological advancements (Faure, 1972). The notion of lifelong learning was also considered to be particularly important, which points to a nominal understanding of the continuous nature of education. In 1996 a report to UNESCO classified learning processes into four main categories, namely learning to know, learning to do, learning to live together and learning to be (Delors, 1996). The final category, learning to be, in particular emphasises the skills needed for individuals to develop their full potential later in the life cycle. This conceptualisation of education provides an integrated and comprehensive view of learning and, with its acknowledgement of the relationship between education in early life and opportunities later in life, constitutes a nominal definition of education quality (Delors, 1996).

UNESCO, through the EFA declaration, the DFA and the FTI and in partnership with the MDGs now promotes access to quality education as a basic human right and supports a rights-based approach to all educational activities (Pigozzi, 2004). Learning is perceived to be affected at two levels. At the level of the student, education needs to seek out and acknowledge prior knowledge, to recognise formal and informal modes of learning, to institutionalise non-discriminatory practices and to provide a safe and supportive learning environment. At the level of the education system a support structure is needed to implement policies, enact legislation and distribute resources and measure learning outcomes to have the best possible impact on learning (UNESCO, 2005c). Further, UNESCO has identified two critical elements that underlie all attempts to define quality with respect to education, namely a focus on the need for cognitive development and encouraging the creative and emotional development of students.

Defining quality and developing approaches for monitoring and improving education systems, especially with respect to the quality of education delivered, requires dialogue designed to achieve:

(1) Broad agreement about the aims and objectives of education;

(2) A framework for the analysis of quality that enables its various dimensions to be specified;

(3) An approach to measurement that enables the important variables to be identified and assessed; and

(4) A framework for improvement that comprehensively covers the interrelated components of the education system and allows opportunities for change and reform to be identified (UNESCO, 2005c).

In most, if not all societies, cognitive development and the accumulation of particular values, attitudes, and skills are important objectives. As discussed, education systems explicitly support the development of these objectives. It follows that improving the quality of education, and thus the development of society, is a universal endeavour. However, the numbers of factors that can affect educational outcomes, such as the socio-economic status of the student's home community, are so many that straightforward relationships between the state of education systems and their products are not easy to determine. Thus, an understanding of the complex processes that drive education systems is needed.

Most educational research seeks to understand the internal processes within complex systems of education by looking at measurable components such as contexts and outcomes. However, there is a general consensus that education systems are comprised of five components reflecting aspects of the education system, namely inputs, processes, outputs, outcomes and context (Scheerens, 2000). Education quality can be evaluated through a combination of indicators, based upon these five components shown in Figure 2.4, that measure the strength of each component, where the specific indicators used for analysis depend on the analyst's perspective as well as the nature of locally available data. The apparent simplicity of the model in Figure 2.4 and the intuitive linkages between the components overshadows the complexity introduced by the relatively large number of indicators that can be introduced to measure each component (the figure shows only a small subset of available indicators for each component, due to space restrictions).

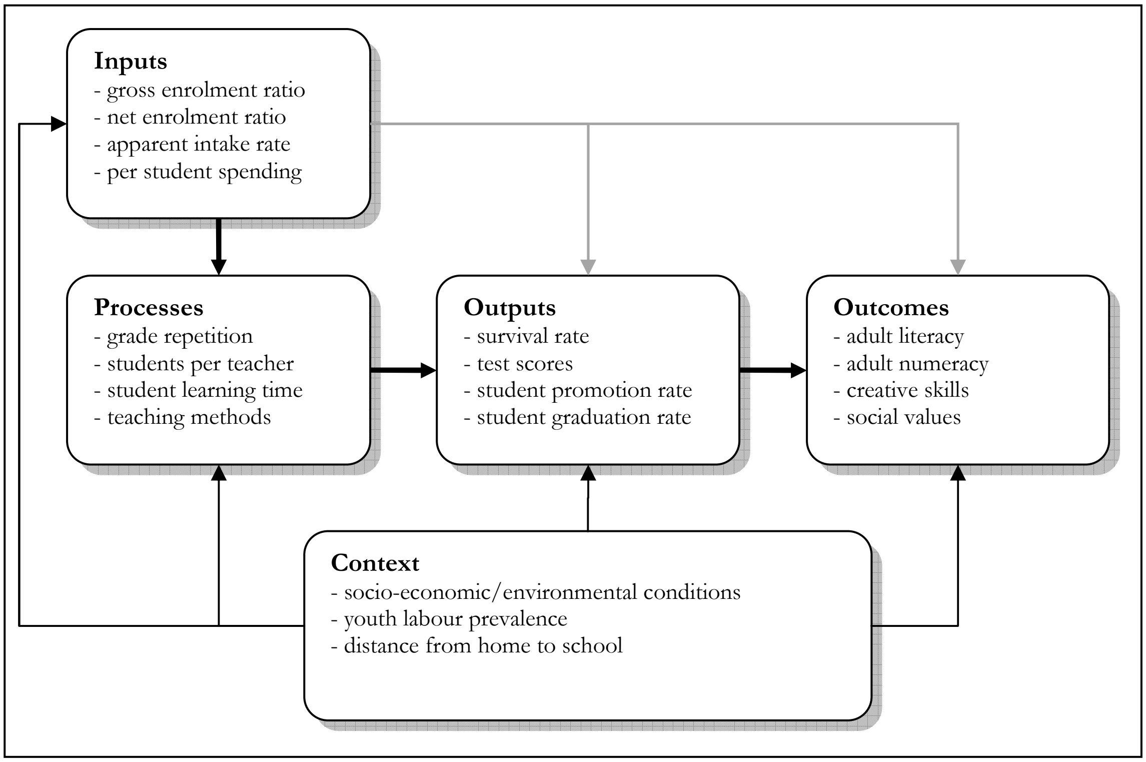


Figure 2.4 – Conceptual model of education systems
(Adapted from Scheerens, 2000 and UNESCO, 2004)

Each component of this model can be represented and measured by multiple indicators. Indicators are numerical representations of a characteristic of a particular component, and can be collected at any organisational or geographical level of aggregation. Indicators at high levels of institutional or geographical aggregation can be used to measure differences in quality between regions or countries. Indicators collected at smaller levels of aggregation allow for complex statistical analysis of the quality of education at individual schools or within communities. However, the ability to collect and analyse data at the individual or even school level presupposes the existence of data collection technologies and systems, as well as the capacity and technical ability to carry out such analyses. As suggested earlier, this is all too often not the case in developing countries.

Effective and appropriate use of this model for analysis of education quality requires prior consensus on the definition and classification of indicators within each component. An added challenge in this respect is the ability to define indicators that measure the process and context components, which have been largely overlooked to date. For example, education quality is typically evaluated using indicators that measure internal efficiency which assesses the system's ability to enrol and successfully promote students through successive grades in the time prescribed (as measured by the GER, NER, AIR, survival and repetition rates). However, this reflects only internal aspects of education quality which are measured predominantly by indicators associated with the input and output components of the education model. This is limiting since an evaluation of quality from a purely internal perspective cannot explain how a student may repeat grades and perform poorly on standardised testing while studying under extraordinary teachers in a positive learning environment (Hernandez-Zavala, Patrinos, Sakellariou & Shapiro, 2006). In addition, a purely quantitative assessment cannot explain the influence of regional policies on the quality of education delivered at the local level (Scheerens, 2000).

For these reasons, a discussion of education quality must be complemented by examining external influences, such as socio-economic and environmental context, on the performance of students within an education system. These external influences are commonly measured by the context indicators in Figure 2.4. Furthermore, an indicator such as absenteeism, which is associated with the process component and can be measured at the student level, can also be used to capture external factors as it links external effects directly to internal results. For example, morbidity due to socio-economic or environmental circumstances may manifest as increased absenteeism which may result in lowered test scores and possible repetition of a grade or in the worst case scenario student attrition.

This external aspect of education quality can only be evaluated fully by evaluating highly disaggregate source microdata at the student or classroom level. At the aggregated super-national regional or national levels common to education system evaluations it is impossible to make comparisons between different geographic or socio-cultural areas within a country, such as comparisons between rural versus urban education quality. Evaluation of indicators at disaggregate levels is required to reveal the extent to which more intangible aspects of quality, such as a school's management, teachers, infrastructure, scheduling and external factors improve learning opportunities for students.

The ability to define and collect the necessary data on indicators that reflect complementary aspects of the education process will ultimately determine the level of insight that can be obtained (Scheerens, 2000). Use of the model shown in Figure 2.4 must recognise that while more emphasis has traditionally been given to inputs and outputs rather than processes and context, measurement of process and context indicators is critical to a full and meaningful analysis of education quality (Bertrand, 2003). The process component is most relevant to the analysis conducted in this thesis, as it recognises the continuous nature of education through measurement of indicators that represent activities which occur continuously throughout the education experience (i.e., both within and between school years).

2.2.2 Education Systems in Developing Countries

Systems of education in developing countries typically lag behind their counterparts in the developed world, due usually to a lack of available financial resources. Additionally, the prevalence of private, semi-private, informal and faith-oriented education systems often is higher in developing countries. This is true especially where heterogeneous populations coexist in a single country, usually divided ethnically or culturally into political sub-units at the sub-national level. Due to a lack of information about the processes that occur in these education systems it is difficult to determine their overall impact on the development of individuals and nations.

The effect of international development efforts such as the EFA declaration, the DFA and the FTI has been in some cases to supplant these informal systems of education, replacing them with more formal Westernised education systems with an increased focus on quantitative measurement of achievements, even where this change may not be desirable or beneficial. This quantitative measurement is often self-serving as it is required to justify sustained donor expenditures to these developing countries (Federici, 2001). In these cases it may be more appropriate to work with existing informal and non-state sponsored education systems to increase their accountability and capacity to collect and share relevant education information, rather than to supplant them in the name of higher and often unrealistic ideals.

Despite these broad concerns, measurement of education systems, whether formal or informal, is necessary in order to evaluate progress towards recognised systemic international goals. The high rate of social and private return on investment in education and the diminishing effect of increased funding to established education systems suggest that understanding the most efficient ways to improve education systems is critical to the appropriate design and application of policy for these systems. This can be clearly demonstrated by looking at the difference in social return on investment for the developing versus the developed world. Developing nations averaged a 20% social return on investment in public primary education during the 1980s, while this figure was only 12% for developed nations (Psacharopoulos & Patrinos, 2004). The difference in these figures can be attributed to the maturity of education systems in the developed world due to massive prior economic input to education systems during the first half of the 20th century. This is a luxury that the largely colonial and in some cases occupied developing world was not afforded at the time (Psacharopoulos & Patrinos, 2004).

Figure 2.5 shows the social rate of return on investment at each level of education for developing and developed countries during the 1980s. The social rate of return for both developing and developed countries decreases with each successive level of education and is equivalent at the highest levels of education. The decrease in social rate of return can be attributed to the cumulative effects discussed previously, as well as to increased public subsidisation at each successive level of education. Additionally, the reduced social rate of return should be viewed against the increased private rate of return in the form of higher wages experienced by individuals who have the ability, capacity or resources to pursue higher education (Psacharopoulos & Patrinos, 2004).

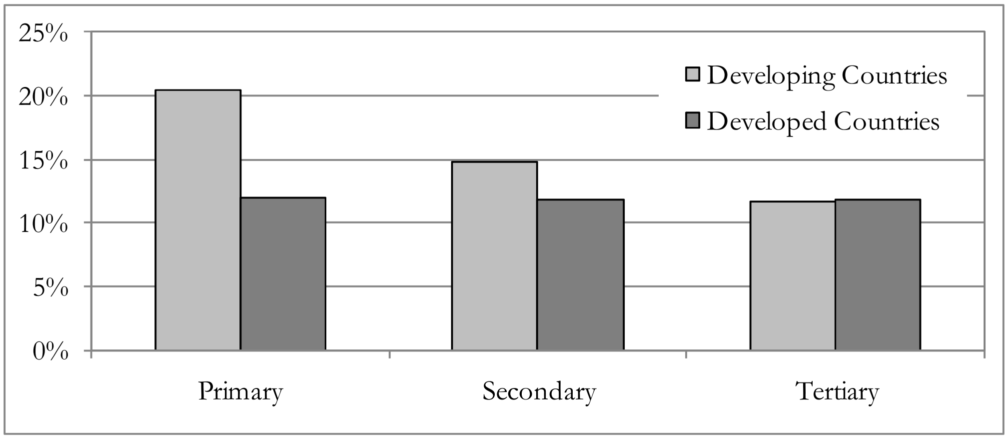


Figure 2.5 – Rate of return on investment by education level during the 1980s (Psacharopoulos, 2004)

One of the main challenges for developing countries in achieving UPC is the rapidly growing demand for education, as shown in Figure 2.6. The global population of primary school age children (which varies from country to country but normally includes ages 5 to 11 inclusive), as well as the global population of younger children (including those aged 1-4 who will require access to primary education in the immediate future) increased by approximately 118 million from 1990 to 2005. Assuming medium fertility rates, the number will continue to increase to a total of about 1.8 billion primary-age students by 2015 (United Nations, 2004). With the assumption of high or constant fertility rates, this number could be as high as two billion by the target year set by the EFA movement for the achievement of UPC (United Nations, 2004). This suggests that achieving UPC will require accounting for all potential students in 2015 and beyond, and not just for current students or expected demand in the immediate future. Furthermore, as the figure shows, the majority of the demand for primary education will come from the developing regions of the world, where the birth rates are highest.

Figure 2.7 breaks this demand down by region, clearly showing that Africa and West Asia are experiencing the fastest growing demand for primary education services. This trend emphasizes the disproportionate challenges that the least developed nations have been faced with, and will continue to face over the next decade, with respect to the achievement of UPC. Specifically, those nations with the least capacity to achieve UPC are faced with the most rapidly growing demand for primary education.

Further confirmation of this trend can be seen by looking at the stagnant or diminishing demand for primary education services in Europe, North America and South America (which is generally considered to be more developed than the least developed regions of the world).

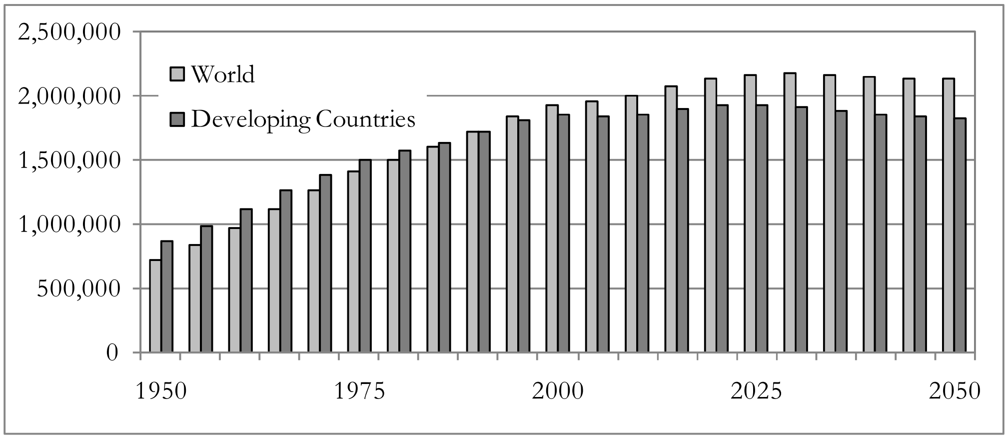


Figure 2.6 – Projected global youth population (in 1,000s)
(World Population Prospects, 2004)

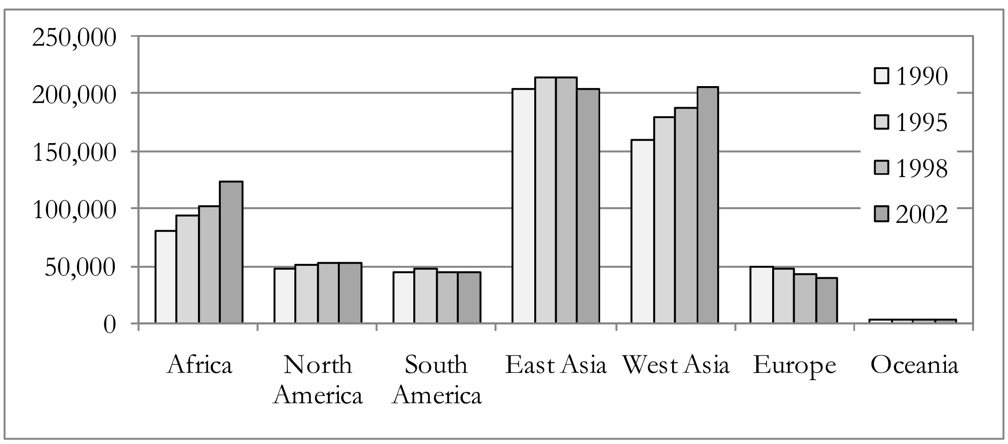


Figure 2.7 – Primary school-aged population by region (in 1,000s)
(Global Education Digest, 2005)

In 2000, the largest comprehensive evaluation of primary education systems to date was undertaken to provide a basis for discussion and opportunities beyond the 2000 deadline of the EFA movement's goals. The evaluation compared the state of education in the developing world between 1990 and 1998, based on the 18 indicators decided upon in the EFA companion documentation (UNESCO, 2000a). The assessment, conducted only at the national and super-national regional levels, was as comprehensive as possible given the data and resources available at the time. This assessment, the first of its kind, highlighted the difficulty of producing a complete assessment of national education systems, particularly with respect to the measurement of education quality.

The core indicators developed for monitoring progress towards EFA mainly address quantitative aspects of inputs to education, thus any in-depth analysis of education quality can only be achieved either through isolated case studies or by interpolation of the quantitative core indicators as proxies of education quality. In addition, data were not available for all countries for all years, thus producing gaps in the analysis. Despite these limitations a broad analysis of the indicators showed statistically significant but non-uniform progress towards achievement of EFA goals over the decade. Education systems in many developing regions experienced minimal improvement, however, in many regions national education systems actually showed signs of stagnation or deterioration (UNESCO, 2000a).

The data collection methodology for the 18 core indicators is now more well-established. In addition to the input indicators previously discussed, indicators which measure the process and outcome components of education are also now routinely collected (such as repetition, dropout, and survival rates) and reported, albeit at highly aggregated levels. UNESCO, the World Bank and other international organisations now regularly publish annual statistical reports on the progress of education system development at the country and regional levels. Recent editions of these annual reports from UNESCO have confirmed a continuation of the trends first discovered during the 2000 comprehensive evaluation.

How education systems in the developing world are handling the growing demand for education, as shown in Figure 2.6 and Figure 2.7 can be understood better by evaluating these systems using indicators that measure each component of the education model presented in Figure 2.4. The input component of education systems can be measured, for example, by indicators such as enrolment ratios, intake rates and spending on education. The process component can be measured by indicators such as repetition, teacher to student ratio, and class size, among others. The output component can be measured by indicators such as student survival rates. The outcome component can be measured by indicators such as literacy and numeracy rates as well as qualitative indicators such as creative and cognitive skills and social values.

Finally, context at national and regional levels can be measured by indicators such as the HDI. Measuring context at the local level requires access to disaggregated socio-economic census and survey data provided at the community or neighbourhood block level. Unfortunately, the EFA movement has yet to incorporate socio-economic context data into their evaluation of education quality, and thus this component of education systems in missing from their analyses and projections. Table 2.1 lists the 18 indicators identified by UNESCO for the four school-based components of education systems for analysis and comparison of primary education systems at the national and regional levels.

Component	Indicator	Description
Inputs	1	Gross enrolment ratio (GER) in organised pre-primary development programs
	2	Percentage of new entrants to primary grade one who previously attended organised pre-primary development programs
	3	Apparent intake rate (AIR)
	4	Net intake rate (NIR)
	5	Gross enrolment ratio (GER)
	6	Net enrolment ratio (NER)
	7a	Public expenditure as a percentage of GDP
	7b	Public expenditure per pupil as a percentage of GDP
	8	Public expenditure on primary education as a percentage of total public education expenditure
	9	Percentage of teachers with qualifications
	10	Percentage of teachers with certificates
Processes	11	Pupil teacher ratio
	12	Rate of repetition by grade
Outputs	13	Survival rate to grade five
	14	Coefficient of efficiency (ideal number of pupil years required to complete primary cycle versus actual)
	15	Percentage of pupils reaching grade four who meet national learning competency standards
Outcomes	16	Literacy rate of 15-24 year olds
	17	Adult literacy rate (15 and older)
	18	Literacy gender parity index (ratio of male to female literacy rates)

Table 2.1 – UNESCO indicators for national level education assessment
(Adapted from UNESCO, 2000)

At the national level, aggregate input indicators such as intake and enrolment rates can be used to produce broad evaluations of education systems, especially with respect to their efficiency. One such indicator is the gross enrolment ratio (GER), which is defined as the total number of students enroled in a particular education level (e.g., the primary level of education), regardless of age, expressed as a percentage of the total population of the eligible corresponding cohort (UNESCO, 2000a). The GER, aggregated at the super-national regional level in Figure 2.8, is a general indicator of the rate of participation in a particular level of an education system. It provides a general measure of the availability and utilisation of school capacity to satisfy the educational needs of the eligible population for a particular level of education (United Nations, 2007a).

Thus, a value of 100% for the GER indicates that the number of students enroled in primary education is equal to the total population of students of the corresponding primary school ages. Values in excess of 100% highlight incidences of under-age and/or over-age enrolment. The presence of over-age students may be explained by late entrance to the school system or by high levels of grade repetition

(United Nations, 2007a). The LAC region shows consistently high values for GER for the 1990 – 1998 time period of the DFA assessment, as well as for the more recent 1999 – 2004 time period as shown in the figure. These consistently high values for GER correspond to large-scale enrolment initiatives throughout the region, supported by the EFA process. The slight and steady decline in the GER over the last several years indicates that the system is reaching equilibrium and has been efficient in enroling the over-aged students who were previously absent from primary school.

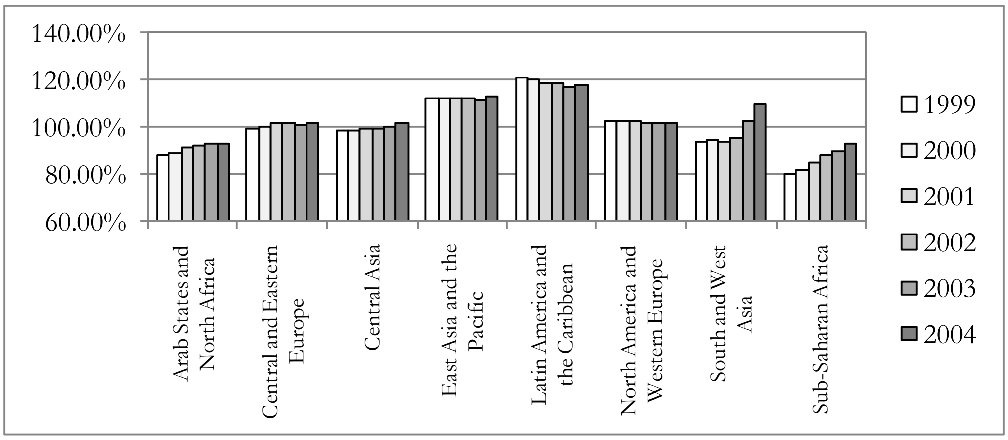


Figure 2.8 – Gross enrolment ratio to primary education by region (UNESCO Institute for Statistics, 2007)

By contrast, the developed regions of Western Europe, North America and Central Asia show near-perfect GER values for all years, as should be expected given the financial and social resources available in these regions to support strong education systems. Of greatest concern is the region of sub-Saharan Africa where, despite support from donor nations and the EFA process, the GER value remains quite low although it is improving slowly. This may be because there are simply not enough schools, and despite clear need, new facilities cannot be opened, staffed with qualified teachers and given the resources required to operate in time to meet the growing demand.

The net enrolment ratio (NER) provides a measure of the extent to which the population eligible (e.g., of the appropriate age) to participate in primary education is actually enroled, and is also expressed as a percentage. By subtracting from current population data, the NER can also be used to gauge the size of the non-enroled primary school-age population (United Nations, 2007a). Figure 2.9 shows the net enrolment ratio aggregated at the regional level. By definition the NER normally should not exceed 100%, as it indicates the percentage of the eligible age-group that is actually enroled. Values of NER upwards of 100% often correspond to countries with large, rapidly expanding populations where outdated censuses do not correlate to annual education enrolment rates.

It is also often possible to see NER values upwards of 100% in developing countries where censuses are sporadic and occur only about once per decade. Depending on the length of time expected to complete primary schooling and the age of entry, it is possible for young students to enter and/or complete primary education before they are officially recorded on a national census. Values of NER in excess of 100% might also occur if a significant number of foreign students are included in the total, although this is less likely in the case of developing countries and at the primary level of education.

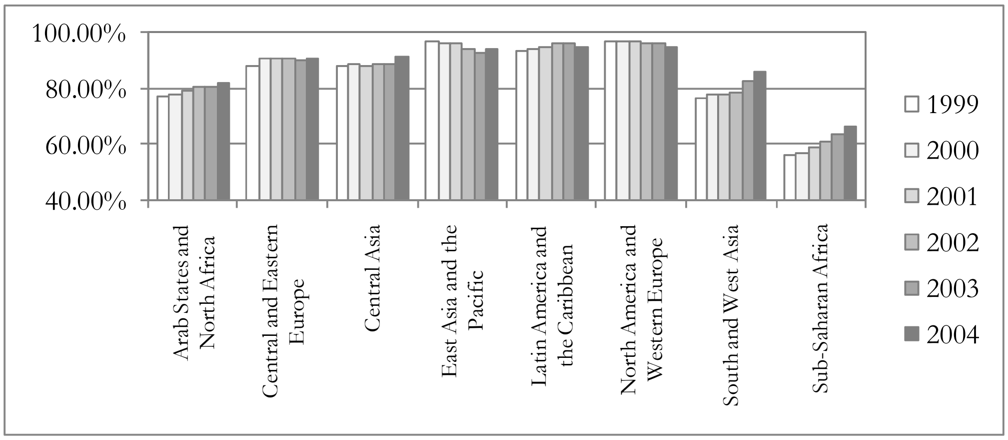


Figure 2.9 – Net enrolment ratio to primary education by region (UNESCO Institute for Statistics, 2007)

Figure 2.8 and Figure 2.9 show that GER values are more variable by region than NER values. The developed regions of North America and Western Europe actually saw a slight drop of 1.2% in the GER from 1999 to 2004. However the GER remained slightly above 100%, indicating full utilisation of the school system. The greatest gains in GER were achieved in South and West Asia, and sub-Saharan Africa, the two least developed regions of the world. The LAC region had the highest GER (averaging 120% for the half-decade), however, the NER for this region was 94.9% for 2004 which suggests that the bulk of the GER value is due to grade repetition and overage enrolment. This would seem to indicate that the education system is highly inefficient and that there is a prevalence of late entry and grade repetition.

Thus, while it appears that the state of education in the LAC region is improving, the quality of education delivered is suspect. Also since sub-Saharan Africa and South and West Asia show strong gains in both GER and NER values, one can conclude that these regions are making substantial progress towards UPC based on these two indicators. Clearly, there is a long way to go still as the GER and NER values are far below optimal, especially for sub-Saharan Africa. North America and Western Europe represent the optimal GER and NER values. What is clear from looking at the trends in GER and NER is that optimal values for both indicators are clearly associated with higher levels of economic development.

The GER and NER, which measure the capacity of education systems, are supplemented by the apparent (gross) intake rate (AIR), which is the total number of new students entering the primary school system expressed as a percentage of the population of official entry age (United Nations, 2007a). While the GER provides a measure of capacity, the AIR is a measure of accessibility. Since AIR focuses on the entry level (Grade 1) of primary school and not the entire cohort of primary students (as do the GER and the NER) it is a measure of the accessibility of the school system at the entrance level. Figure 2.10 shows the AIR aggregated at the super-national regional level.

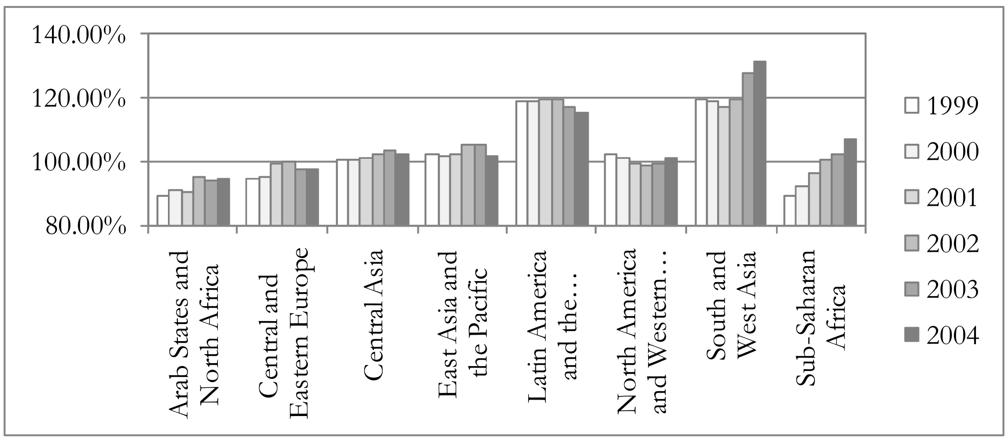


Figure 2.10 – Apparent intake rate to primary education by region (UNESCO Institute for Statistics, 2007)

Lower values of the NER, in combination with higher values of the AIR, as seen for the developing regions, indicate that many new students entering school in the first grade are not of the official entry age (e.g., they are usually overage entrants) (United Nations, 2007a). The reverse situation is true for developed regions, indicating that the education system is performing well with respect to the accessibility and enrolment of students of the appropriate age. This situation also corresponds generally to less grade repetition within the education system (United Nations, 2007a). The greatest gaps between the AIR and the NER occur in sub-Saharan Africa and South and West Asia, but are also large in other developing regions such as the LAC region. The increasing values of the AIR in regions such as sub-Saharan Africa suggest that the capacity and accessibility of education systems are increasing in that region.

However, most of the population being reached in these regions most likely includes children that were previously unable to access the school system. This indicates that education systems in this region are achieving progress towards UPC despite the fact that the regions that exhibit this trend also tend to have less than the required capacity to meet growing education demand. The large proportion of late entrants to primary education in these regions also limits the accessibility of education to the population of official age. Finally, dramatic increases in the AIR, if not accompanied by large increases in resources such as classrooms, teachers and teaching materials could actually correspond to reductions in education quality.

In areas where state funding of education dominates, an examination of public expenditure per pupil can reveal the level of economic resource commitment to the education system by national governments. Figure 2.11 shows that public expenditure per pupil is highest in the developed regions, and low, yet highly variable for developing regions. To maintain the quality of education inputs in the face of rapidly growing demand, the spending per student should at least remain unchanged. However, regions such as East Asia and the Pacific, and South and West Asia show a steady decline in per student spending, suggesting that national education budgets in these regions have not kept pace with growing demand.

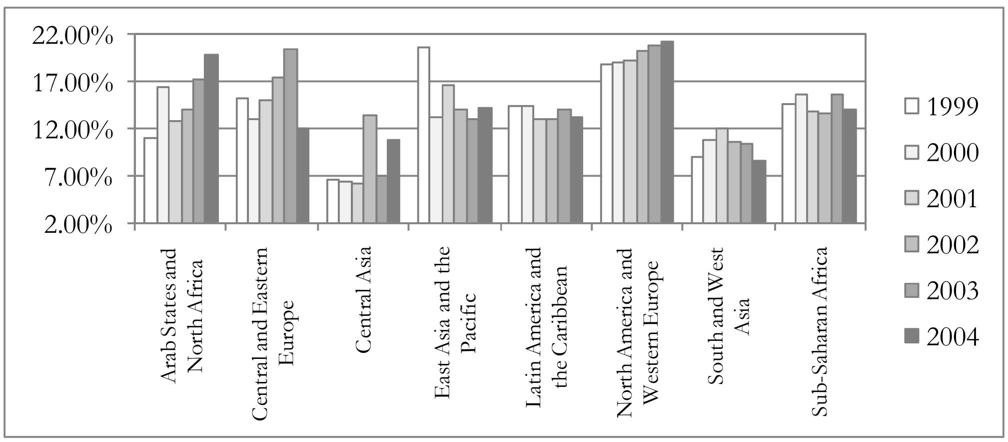


Figure 2.11 – Public expenditure per pupil by region (as a percentage of GDP) (UNESCO Institute for Statistics, 2007)

A more relevant analysis of education quality requires the process component of the model described in Figure 2.4 to be considered as well. One common measure is the ratio of students per teacher. High ratios of students per teacher indicate that students may be receiving a less effective education, as each teacher is expected to handle a large number of children at a given time. Figure 2.12 shows that ratios of students per teacher have been steady for less developed regions, have increased overall for the least developed regions and have dropped by a small amount in the most developed regions. This indicator clearly reveals that some of the proclaimed progress towards UPC has come clearly at the expense of education quality. The rising demand, due to population growth and the increased enrolment or intake rates in developing countries, has not necessarily been matched by an increase in the number of teachers in general and adequately trained teachers in particular. This trend shows, again, that the regions that are least capable of achieving UPC are facing the greatest challenges with respect to education quality.

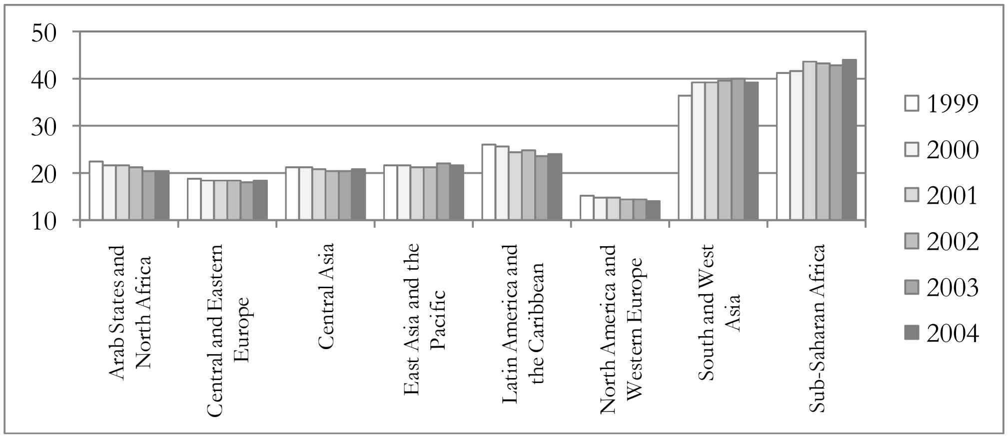


Figure 2.12 – Students per teacher by region
(UNESCO Institute for Statistics, 2007)

Further insight into the quality of education can be gained by looking at student repetition rates. High repetition rates indicate that a significant proportion of students are not being promoted annually through each grade, suggesting poor performance, poor attendance and/or the inability of the school system to prepare students for the challenges of each successive grade. Figure 2.13 shows that the percentage of student repetition at the primary level has been declining overall. Sub-Saharan Africa again performs poorly on this indicator with the highest repetition rate of any region although the percentage has been decreasing. Data for this indicator were not reported from the majority of countries in Central Asia and this region is omitted from this analysis. The LAC region showed a steady increase in repetition until 2004 with a sudden reversal of the trend when it dropped suddenly to the lowest rate during the half-decade. While this may be a sign of improvement in the education system, it may also be an error due to under-reporting or incorrect reporting of data. This highlights the dangers of looking at highly aggregated data because the specific reason for this significant change in trend cannot be determined at this level.

While the percentage of repetition has fallen in general over the half-decade examined, developing countries are clearly still struggling to improve education quality in the face of limited resources. The continuing high repetition percentages in developing regions indicate that schools in these regions are ineffective in increasing cognitive abilities, as well as improving life skills for their students. What cannot be learned from these indicators is the extent to which absenteeism contributes to grade repetition. Absenteeism is known to contribute to repetition, due to the inability of students to complete end-of-year testing and review because of lack of instruction time (Kearney & Bensaheb, 2006). However, the role of absenteeism, since it is a local level phenomenon, relative to other factors that limit learning cannot be defined precisely at this level of aggregation.

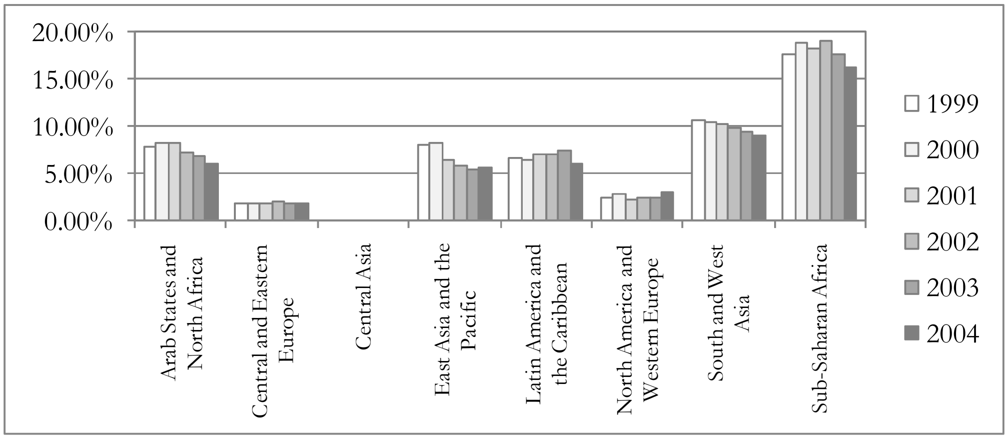


Figure 2.13 – Student repetition rate by region
(UNESCO Institute for Statistics, 2007)

Student survival is a further indicator of education quality and is defined as the percentage of students who are successfully promoted through to the end of a particular level of an education system within the time prescribed. High percentages of repetition have been shown to contribute to reduced survival rates, as there is less incentive for parents to continue sending their children to school when the education is proven to be of little value (i.e., of low quality). Where children contribute to family well-being through paid or unpaid labour, the inability to complete successive grades makes primary and secondary education a progressively less attractive option. Figure 2.14 shows that student survival and repetition rates are inversely correlated, with high repetition rates corresponding to lowered survival rates. While sub-Saharan Africa again performs very poorly on this indicator, the East Asia and the Pacific region seems to suffer a disproportionately low survival rate relative to their grade repetition rates. This is suggestive of high levels of child labour in this region.

Ultimately, education systems have very specific goals such as developing the cognitive abilities of students, teaching life skills and increasing creativity. Thus, the effectiveness and efficiency of education systems in the achievement of these goals is of particular interest. Various ways of assessing the effectiveness of education systems include measuring the ultimate outcomes of education. Outcomes are most often evaluated through standardised testing that measures skills and knowledge based on predefined standards and requirements. However, such data are not available in many regions of the world, largely due to a lack of resources and infrastructure to conduct large scale testing. There is also a lack of consensus on what specific aspects of education are most important, and how different aspects of learning can be measured definitively. As a result, there are few data that are available readily for an effective comparison between individual countries or sub-national regions within a country (United Nations, 2007a).

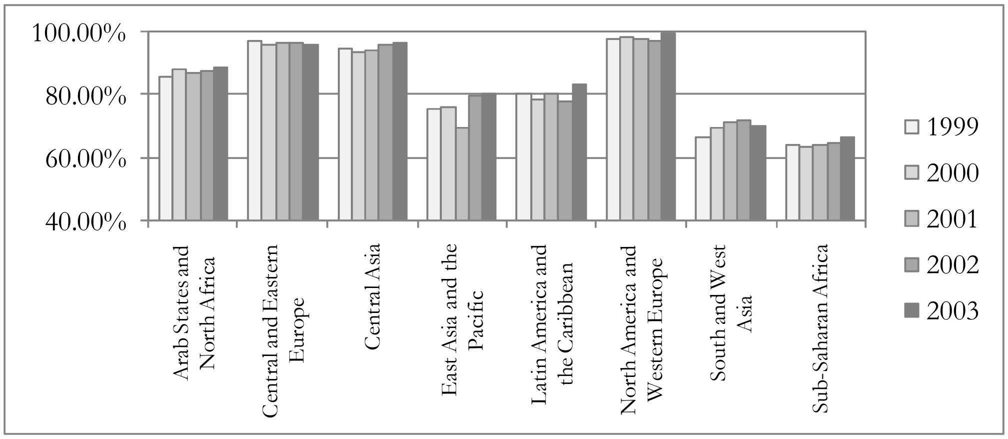


Figure 2.14 – Student survival rate by region (UNESCO Institute for Statistics, 2007)

Literacy is the most commonly used measure for education outcomes, and is generally considered an appropriate proxy for measuring the quality of education. Literacy is one of the few international development initiatives that have made relatively consistent progress worldwide. Figure 2.15 shows youth literacy rates (ages 15 to 24) by region, which measures the combined outcome of both the primary and secondary levels of education. While the less developed regions lag behind more developed regions, they show a much stronger gain during the half-decade, pointing to the benefits of international literacy awareness campaigns. However, despite this strong growth, the least developed regions are unlikely to reach and maintain DFA and FTI target levels of 80% youth and adult literacy by 2015, and certainly seem unable to reach the penultimate goal of 100% literacy worldwide (United Nations, 2007a).

High youth literacy rates in North America and Western Europe suggest that primary and secondary education systems in these regions have excelled at preparing students for opportunities beyond graduation from formal primary and secondary education. A study by Statistics Canada has shown that adults with average or higher than average literacy skills are approximately three to six times more likely to be in the top quartile of personal income when compared to adults with below average literacy skills (Kearney & Bensaheb, 2006). Although encouraging as a broad measure of the quality of education, literacy rates must be considered relative to the other indicators discussed in this section. Regions and countries that score poorly on the other indicators discussed above are likely to have larger proportions of the overall population (at all ages) unable to read and write, although the very high youth literacy rates in the LAC and East Asia and the Pacific regions is very encouraging.

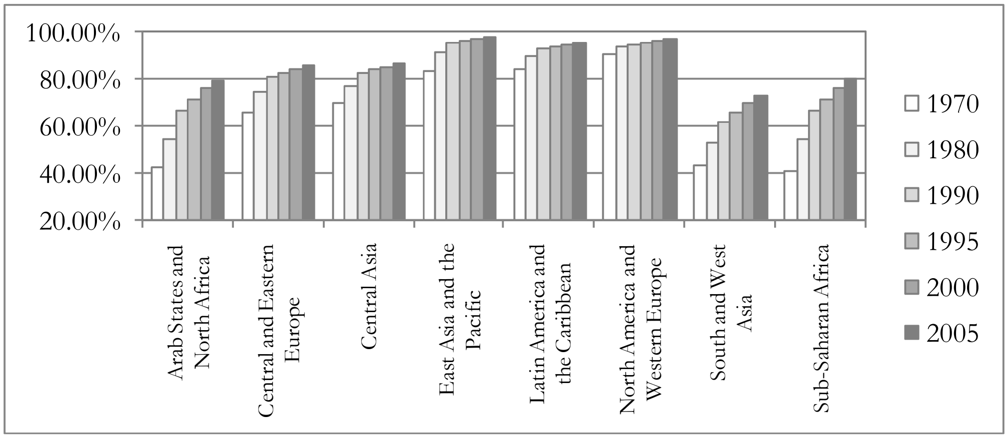


Figure 2.15 – Youth literacy rate by region
(UNESCO Institute for Statistics, 2007)

It is important to note that any improvements in education quality, as measured by outcome-based indicators, lag by at least a decade at the primary school level any policy changes or other changes to input-based indicators to the system. The reason for this lag is based on the average time it takes for students who begin primary school under a new policy regime to reach the youth age cohort (ages 15-24) where these outcomes can be measured with respect to the five component model. This again speaks to the continuous processes that underlie education systems, and should be raised as a caution to those seeking immediate increases in education quality as a result of policy changes based on the indicators described above.

Outside of measures of literacy, comprehensive data are lacking for the measurement of ultimate, long term outcomes in developing countries such as earning potential later in life and other measures of long-term personal and social return on investment. In addition, the 18 core EFA indicators do not contain any measures of the context component of education systems as shown in Figure 2.4. Context is commonly measured by socio-economic and environmental indicators. At the regional level, aggregate contextual measures, such as the United Nations Development Programme's (UNDP's) HDI can reveal patterns of increase and decline in overall development. Analysis of the HDI over the past decade shows continual improvement for the richest countries and continued decline among the least developed countries (UNDP, 2006). However, this measure is not available for less aggregate levels of analysis.

As the discussion in this section has pointed out, the reliance on aggregated data is a significant limitation of the indicators used in the EFA evaluation process. While aggregated data is more economically feasible and does not place unnecessary administrative demands on the administrative structures of education systems in developing countries, these data do not adequately address the local level needs of teachers, parents and students. It is precisely because of this reliance on highly aggregated data that important socio-economic context and process indicators may be overlooked in the assessment of education quality. Thus, indicators of these, and all, components of the education system shown in Figure 2.4 are best evaluated at local levels, such as at the level of the student, classroom and school.

This section has not examined all of the possible measures of education system quality. However, it has covered the major dimensions defined in the EFA declaration, the DFA and the FTI, and corroborates the general trends noted during the DFA evaluation conducted in 2000. Several general conclusions can be drawn from the analysis of the available regional data. First, there is a clear and consistent geographical distribution in education development based on each indicator. Countries in sub-Saharan Africa tend to have the worst performance in terms of education development, followed by countries in South and West Asia, and then the LAC region.

In contrast developed regions, most notably North America and Western Europe, typically show slight improvement over time, even though they were at or near the goals of EFA in 1990. Overall, less developed regions, such as the LAC region, often show significant improvements, while the least developed regions are usually the most variable in terms of education quality and are more likely to have seen stagnation or deterioration of their education systems. This suggests an urgent need to achieve UPC such that the development needs of the poorest countries can be met.

However, the analysis so far has been dominated by quantitative measurement of the internal efficiency of education systems with respect to the capture and processing of students. Internal efficiency is defined in largely utilitarian terms with respect to education systems and in this sense refers to education systems that successfully capture students at the appropriate age and promote them through the system without repetition or attrition. Whether or not students are prepared and capable of continuing on to successive levels of education is not considered by this analysis. Thus, the concept of efficiency includes no notion of the experience of education or of the amount a student is able to actually learn and benefit from the education received.

Absenteeism is also a measure of internal efficiency of education systems as it correlates to both grade repetition and attrition and is the manifestation of socio-economic factors based in the student's community and/or neighbourhood. However, absenteeism's link to exogenous contextual factors extends the importance of this indicator, which has been noted in numerous studies, and mitigates the utilitarian evaluation described thus far by acting as a proxy for the socio-economic and environmental realities of the student manifest in the experience of education (Park et al., 2002, Breiter & Light, 2006). Unfortunately, despite the clear need for these absenteeism data, they are typically not systematically collected or analysed, due to time and resource constraints placed on teachers to collect and report these student and class level data. The next section discusses the importance of absenteeism as an indicator of the quality of education, and discusses the linkages between absenteeism, health and context.

2.3 Absenteeism

Absenteeism is defined as time when a student does not attend school while school is in session, and is typically expressed as either days or hours of schooling that have been missed (Park et al., 2002). Total absenteeism refers specifically to the cumulative loss of instruction time accrued by a student in relation to the cohort of her/his peers over a given time period, and includes both legitimate and illegitimate absenteeism. Reasons for illegitimate absenteeism include the refusal of a student to attend school, difficulty remaining in classes for an entire day and students skipping classes or full days in the school week (Kearney & Bensaheb, 2006). Legitimate absenteeism refers to unavoidable absences due to health or family reasons (Benavot & Gad, 2004). In either case, absenteeism does not refer to normally scheduled school days when classes are not held due to external interferences such as poor or violent weather, strikes or other political actions or systemic conditions, including the inability of the state to operate the school system continuously. Measures of total instruction time, such as days or hours of instruction, are more appropriate indicators for assessing the overall opportunity to access continuous learning at a particular school, district or education system.

Teacher absenteeism, defined using the guidelines described above, also has a significant negative effect on student achievement. Studies which have explored teacher absenteeism found strong negative correlations to student numeracy and literacy (Suryadarma, Suryahadi, Sumarto & Rogers, 2006). While a problem for all education systems, teacher absenteeism is systemic to public education systems in developing countries and not as prevalent in their private sector counterparts. Public school teachers in developing countries are often burdened by poor wages and low job satisfaction, which leads to a reduced sense of responsibility and manifests in poor teacher attendance (Chaudhury, et al., 2005). Teacher absenteeism is also more prevalent in rural areas, as teachers often commute to work from urban centres. In these situations teachers are often required to pay for their own transportation which can cost them up to half of their daily wage (Chaudhury, et al., 2005, Garcia, 2005). In some cases, it may be necessary for teachers to remain in the communities where they work during the school week, which constitutes an added economic and social burden for the teacher. While teacher absenteeism is a critical indicator of the process component of education systems, this thesis will focus only on the issue of student absenteeism and its effect on education quality.

Although notions of instructional time vary considerably, there is general consensus on the need for minimum standards in instructional time (Benavot & Gad, 2004). These standards, such as engaged learning time, actual instructional time, and maximum allowable missed time, are normally set by education planners at the national level. These absenteeism policies can and do not accommodate differences in socio-economic or environmental context of individual communities and districts, including the differing lengths of school years between urban and rural areas. Thus, the following sections explore absenteeism at the local level and include consideration of the reasons for absenteeism. The concepts of engaged learning time and the effect of absenteeism on student achievement are also discussed. The argument for inclusion of absenteeism as an indicator of education quality is outlined and justified. In the final section the complex relationship between health, context and absenteeism is discussed.

2.3.1 The Effect of Absenteeism on Education Quality

Achievements in education are cumulative, meaning that acquiring new skills, developing cognitive abilities and increasing creative and emotional development are dependent on continued and sustained access to education of high quality. This concept is integral to the goal of UPC, which goes beyond mere access to and availability of education to state that continued access to high quality education is critical to ensure access to future opportunities later in the life cycle (World Bank, 2004b). Therefore, learning can be seen as a continuous process, and academic achievement, as a measure of learning at the individual level, can be calculated as the product of personal ability and engaged learning time (Carroll, 1963).

Interruptions to learning, in the form of absenteeism, affect student outcomes in two ways. First, both long sustained or short, repeated absences impair the student's ability to remain on pace with peers and reduce the ability of the student to understand and synthesise new material presented in the classroom. Second, absenteeism reduces the overall engaged learning time for a student (the actual time spent in instruction during the school day) and thus is considered to be a critical factor in achievement (Carroll, 1963). Benavot and Gad (2004) note that while many studies do not dispute the consistent and positive association between reduced learning time and lowered academic achievement there is considerable dispute concerning the magnitude of this relationship. Without controlling for the influence of externalities such as socio-economic status, student aptitude, prior knowledge and teaching methods the effects of increased learning time may be overstated (Benavot & Gad, 2004). However, it is clear that increased instructional time does enhance a pupil's exposure to knowledge and results in correspondingly significant learning gains.

Thus, absenteeism is related directly to the quality of education as it represents the amount of engaged learning time a student has missed in relation to her/his peers. As noted earlier, absenteeism can be divided into legitimate and illegitimate categories. There are two types of illegitimate absenteeism that directly affect the quality of education a student receives (Bureau of Educational Research, 2004). Prolonged absenteeism refers to single continuous episodes of absence from school, measured on a scale of weeks of instruction time missed. Chronic absence refers to multiple discontinuous absences, measured in terms of days per instance. It is possible for a student to experience both types of absences during an academic year, however, the causes and effects of each type of absenteeism differ greatly. For example, prolonged illegitimate absenteeism may be the result of peer victimisation or other social adaptive issues (Robinson, 2006).

Prolonged absenteeism often results in academic underachievement and increased risk of attrition (Crist, 2002). Chronic absences, on the other hand, are largely due to school refusal behaviours or problems within the home, such as the need to help an elderly or infirm parent, the need to work to supplement family income or the inability of parents to afford to send the child to school on a regular basis (Bureau of Educational Research, 2004). Research in developed countries shows that youths who refuse to go to school often display 'internalising problems' such as general and social anxiety, worry, fear, self-consciousness, depression and suicidal behaviour, fatigue and somatic complaints (Kearney & Bensaheb, 2006). There is no specific definition of what amounts to chronic absenteeism, however there is a general consensus, in developed countries, that chronic absenteeism occurs when the student misses between five and 10 percent of the instruction time offered in a school year (Crist, 2002).

Key short term consequences of absenteeism include incomplete school work and academic failure, alienation from peers and substantial family and parent-to-school conflict. In developed countries, key long term consequences include potential attrition, delinquency, economic deprivation, later occupational and marital problems and need for further psychiatric assistance in adulthood (Kearney & Bensaheb, 2006). In fact, research on school attendance consistently shows that low levels of absenteeism are correlated to positive school behaviour, increased participation in extracurricular activities, higher grades and better long term educational outcomes. Unfortunately, the vast majority of research into absenteeism has been undertaken in developed countries, namely the United Kingdom (UK) and the US.

Legitimate prolonged absenteeism is largely the result of child labour or morbidity, the former being a staple of developing nations, and the latter applying to both development contexts. This absenteeism is legitimate in the sense that it is not the student's choice to be absent from school, but rather the influence of an external factor (e.g., the need to work due to extreme poverty or the inability to attend due to severe or infectious illness). In some regions, especially rural areas of developing countries, seasons of increased agricultural activity have associated high rates of prolonged absenteeism. These areas can also suffer from legitimate chronic absenteeism in the form of increased absenteeism on regular market days (UNESCO, 2004).

The school year is not an internationally standardised unit, and thus the actual instruction time in an education system varies greatly between and within education systems (David & Lopez, 2001). The largest disparity in instruction time is generally seen within education systems in areas that are neither predominately urban nor rural, but contain a significant proportion of both. Reasons for shortened instruction time include lack of resources (facilities, teaching materials, teachers) on the part of the education system leading to facility and resource sharing (for example, primary classes held in the morning and secondary classes in the afternoon). In developed countries education systems allocate an average of 750 official annual instructional hours for primary students, with a small percentage of this time dedicated to non-instructional activities such as lunch, breaks between classes and play (Benavot & Gad, 2004). There is no corresponding average for developing countries. However, it is clear that in developing countries, where access to primary education is already reduced by socio-economic, environmental and geographical factors, any interruption due to absenteeism has a correspondingly larger impact on the quality of education a given student receives.

Finally, increased absenteeism can be a product of the education system itself. For example, in rural areas of developing countries the push for increased enrolment has often lead to preference being given to older, non-enroled children, thus limiting opportunities for children of the appropriate entry age. This is especially apparent in education systems where there is a lack of functioning schools within walking distance of rural communities, and where increased enrolment is not accompanied by increased resources for the construction of new schools or the expansion of existing schools. These issues coupled with insufficient student support both at home and in school often lead to increased absenteeism (Houghton, Gleeson & Kelleher, 2003). As noted earlier, increased absenteeism leads to increased dropout and repetition rates, which inhibit students from participating in secondary school in a timely fashion. Completion of secondary school in a timely fashion is critical if the benefits of investment in education are to be recognised (Reid, 2006). Thus, absenteeism can be seen to impact on the quality of education in multiple ways.

2.3.2 Linkages between Health, Context, and Absenteeism

Many studies have shown that health is affected directly by socio-economic and environmental context (Houghton, Gleeson & Kelleher, 2003). Moreover, poverty is highly correlated with increased morbidity for young students (Zhang, 2003). Poverty in this sense refers to multiple elements of deprivation including low household income, poor housing conditions, high unemployment rate and severe climatic conditions (Zhang, 2003). Despite limited research in this area, school absenteeism is considered an appropriate proxy for the health status of children, and thus absenteeism is thought to be negatively correlated with student achievement and positive future outcomes (Houghton, Gleeson & Kelleher, 2003). Confounding the issue is the fact that the effect of morbidity on education quality cannot be directly measured as students may be present at school even when they are in a state of reduced health.

A state of morbidity directly affects the student by increasing attention deficits and reducing cognitive potential and indirectly undermines education systems through increased absenteeism, grade repetition and attrition (UNDP, 2006). These effects are exacerbated at the earliest levels of education including the primary school level where most students establish their attendance and non-attendance patterns (Currie, 2005). Increased morbidity is highly correlated to physical, environmental and socio-economic factors that are beyond the control of the child (Özmert et al., 2005). In addition, socio-economic status, recognised as one of the most significant predictors of student performance, is also one of the strongest predicators of absenteeism in developed countries (Boey, Omar & Phillips, 2003). Health problems also affect a child's school performance in more acute ways. For example, chronic illnesses such as asthma, the most common chronic illness affecting children globally, is a main contributor to grade repetition at the primary and secondary levels in North America and Western Europe (Boey, Omar, & Phillips, 2003, Park et al., 2002, Currie, 2005).

The linkages between health and development have been recognised as part of international development discourse since the Alma Ata Health for All (HFA) Conference in 1978. At this conference it was stated that good health is critical to individual development, especially in the earliest years (Pan American Health Organization, 1978). Article 7, paragraph 4 of the Alma Ata Declaration formally stated the linkages between social systems that contribute to health:

> (4) Involves, in addition to the health sector, all related sectors and aspects of national and community development, in particular agriculture, animal husbandry, food, industry,

> education, housing, public works, communications and other sectors; and demands the coordinated efforts of all those sectors (Pan American Health Organization, 1978).

It has also been shown that disparities in children's health conditions impair school readiness (Currie, 2005). Thus the effect of health on student performance and attendance begins even before entrance to the primary level of school. Impaired school readiness upon entrance to the primary level of school may lead to poor performance in early years and often leads to increased attrition rates as well as self-esteem problems (Özmert et al., 2005).

The environment in which the student learns must also be conducive to health. The severely reduced quality of education experienced at schools with no access to clean water or sanitation is powerful evidence of the interconnectedness between health and education. Simply stated, it is not possible to build effective education systems when children are constantly experiencing conditions of reduced health and/or are unable to attend school. Furthermore, UPC cannot be achieved when girls are kept at home because their parents are worried over critical health and safety issues such as the absence of separate toilet facilities (UNDP, 2006). Ironically, the bulk of health-related absenteeism comes from infections such as the common cold and the influenza virus and other relatively minor sicknesses that can be controlled through simple remedies and/or prophylaxis.

Finally, research has shown that children with infections are twice as likely to be absent from school as those without (UNDP, 2006). When children attend school in a state of reduced health their performance and achievement is significantly lowered and their presence runs the risk of spreading the incidence of infection among other students. Several studies have discovered adverse effects on memory, problem-solving skills and attention spans suffered by students attempting to learn while experiencing a state of reduced health (UNDP, 2006). Finally, it is clear that a clean environment, both indoors and outdoors, will not only promote the physical health of children but will also promote the cognitive development of new generations.

2.4 Summary

This chapter has provided the context for this thesis by discussing the nature of early childhood education and its importance in the development of individuals and nations. Education systems in general and education quality in particular were discussed at the international level, with a focus on the role of quality education in the development process. The international community has used the EFA declaration, the DFA and the FTI, as well as other global forums, to promote awareness of education and health development issues internationally and to set consistent frameworks for international discourse and action. An evaluation of existing international conditions of education quality revealed that disparities in education quality at the international level remain prevalent, and that there is an urgent need to re-evaluate the relationship between donor and recipient countries so as to maximise gains towards the achievement of UPC, especially with respect to education quality.

While various perspectives or approaches can be taken for the evaluation of education quality, a general conceptual model of the education process using five components to represent inputs, processes, outputs, context and outcomes seems to reflect best the continuous nature of education and the intrinsic need for quality of education in that it is intuitive in its general form yet flexible enough to allow for the addition of new indicators. This model forms the basis for the measurement of education quality in the Province of Maynas in Peru used in this thesis. Finally, this chapter explored the issue of absenteeism and the influence of health on absenteeism and by extension school performance and future outcomes for students. An exploration of the linkages between health, absenteeism, student performance and school quality guides the analysis and discussion presented later in this thesis.

Chapter 3

Information and Technology for Education Planning

This chapter discusses the contributions that information and technology make to education planning and decision-making processes. The first section discusses the role of information in supporting decision-making processes in education planning and the importance of education management information systems (EMIS) in supporting these processes. Next, the specific information needs of education systems in developing countries are explored. The second section of this chapter discusses the role of spatial information technologies (SITs), with specific reference to geographic information systems (GIS), for planning and decision-making in education systems in the context of both developed and developing countries. An examination of the importance of understanding how spatial relationships contribute to the assessment of education systems at the local level follows. The chapter concludes with a discussion of the challenges and opportunities for technology adoption and extended data analysis, including EMIS and GIS, as a result of the rise of the information society in developing countries.

3.1 The Role of Information in Education Planning

Assessment of education systems cannot confidently be undertaken in the absence of relevant, current and complete data (Breiter & Light, 2006). In addition, any assessment of a system as complex as national education systems can only be undertaken using appropriate data analysis tools that support probability-based statistical analysis. To this end, as previously mentioned in Chapter 2, the Dakar Framework for Action (DFA) and the Fast-Track Initiative (FTI) both included specific recognition of these important concepts and called for the adoption of information and communication technologies (ICTs) to support the collection, sharing, and dissemination of education-based data (UNESCO, 2006).

However, the evaluation paradigm introduced by the EFA declaration and subsequent declarations was centred on a one-way flow of data beginning with the collection and reporting of data from the school level to local education authorities and ending with aggregation and consolidation of these data at the national level. The EFA movement to date has not recognised specifically the importance of a reciprocal flow of information and knowledge derived from these data back to the sub-national and local level reporting units. However, without this reciprocal flow of information and knowledge, data collection at the local level becomes merely an exercise in justifying top-down efforts to produce tangible numerical improvements in the education systems of developing countries, rather than an effort to achieve democratic dialog to positively affect the quality of education delivered at the school level. With this in mind, Figure 3.1 shows the ideal flows of information and data within an education system that would be required to meet this latter goal.

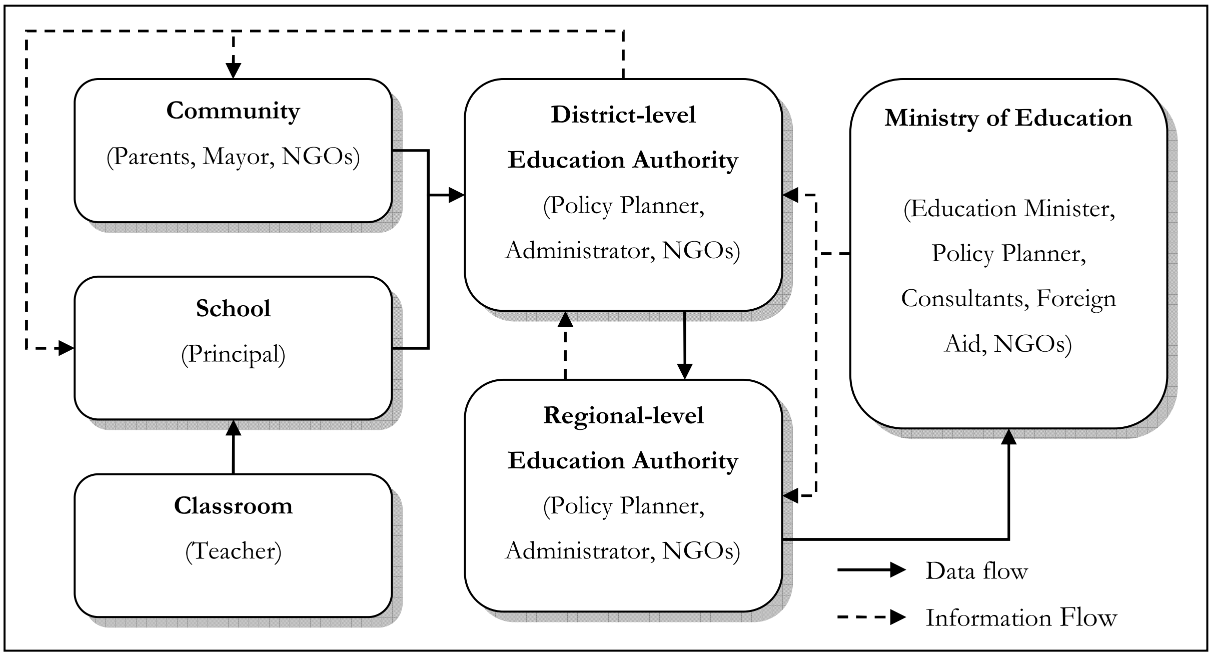


Figure 3.1 – Ideal information and data flows in an education system

Increasing education quality translates into the provision of a more positive learning environment, which is one of the core goals of the EFA movement. However, as noted previously, the 18 core indicators introduced by the EFA companion document do not adequately capture all five components of education systems. Thus, the first step in improving the evaluation of education systems involves increasing the range and scope of the indicators that are reported currently to improve the focus on education quality rather than on measuring internal efficiency in the use of resources and funds (UNESCO, 2000a). However, this shift towards a more holistic analysis of education systems requires a larger investment of time and resources by education practitioners at the local level and is possible only where there is sufficient penetration of and capacity to use ICTs. ICTs are critical tools for the timely and accurate collection, reporting and dissemination of large amounts of data among multiple non co-located stakeholders, such as is common to education systems (UNESCO, 2006).

The shift in focus precipitated by the adoption of ICTs and the awareness of the shortcomings of the model proposed in the EFA companion document (i.e., the 18 core indicators) has also increased awareness of the importance of ongoing and not merely static year-end reporting and evaluation of education information. Shifting the focus of evaluation away from inputs (which measure the immediate impact of policy) to outputs and outcomes (which measure the longer-term aspects of education systems) has also revealed time-lagged disparities between resources input to education systems and the ultimate outcomes generated by those inputs for successive cohorts of students (UNESCO, 2000a). For example, as noted earlier, increased education funding in France did not translate into increased achievement on standardised tests. This suggests the presence of intervening influences occurring in the process and context components of education systems, such as absenteeism, which need to be measured along with the other components of the education system in order to gain an holistic understanding of the quality of education being delivered at the local level.

In addition, it is clear that the processes of education and the socio-economic context of students are both local level phenomena that do not take place at national or international levels. Thus, while evaluating education systems at these aggregate levels is useful and informative, this aggregate analysis cannot reveal to education planners the needs, challenges and opportunities of individual schools and communities which vary at the local level. A complete evaluation of education systems and education quality measures not only the five components of an education system, but also measures education quality at all levels of institutional aggregation from the classroom to the national level. For example, while progress towards key UPC goals such as universal literacy and learning achievement may seem substantial when these indicators are aggregated at the national or regional level, this aggregation masks growing and unacceptable disparities within and between the communities from which the statistics are reported (Ordoñez, 2000).

Clearly, education system evaluation and planning must be undertaken at all institutional levels, with each level holding different responsibilities and mandates. At the national and sub-national levels education ministries should be largely responsible for the development of policies that determine the distribution of financial and physical resources as well as setting local-level management responsibilities and school curricula based on national goals. Policies at this level are typically evaluated on a yearly or semi-yearly basis and are based on an analysis of aggregate data at higher institutional levels. By contrast, at the local level of education systems, including individual schools and classrooms, planning and decision-making processes take place on an ongoing day-to-day basis. These processes are informed by the qualitative experiential knowledge of teachers and principals relative to their particular circumstances which vary from one school and/or district to another. Clearly, national policies are only effective where they are flexible enough to take into account, to the maximum degree possible, the local knowledge and experience of daily practitioners such as teachers and school principals (Breiter & Light, 2006).

Extraneous or irrelevant information also must be filtered out and poor quality data cleaned before they are used for evaluation purposes. Without this screening, decision-making is likely to become prohibitively complicated and may overwhelm education planners. These extraneous data may also add uncertainty to any statistical analyses conducted with these data (Breiter & Light, 2006). Thus, building effective EMIS requires an understanding of information requirements, including how the necessary data might be collected, cleaned and input to the system, and how data, information and analytical results may be communicated internally and externally to education stakeholders and thus utilised to support appropriate and sensitive policy planning and decision-making.

The following section discusses in more detail the ways in which education-based data are generally collected and analysed within education systems, and discusses the generic EMIS platform developed by UNESCO that is provided under public license to education stakeholders via the Internet. This is followed by a summary of specific issues related to education information systems in developing countries.

3.1.1 Information Needs of Education Systems

Education management information systems (EMIS) are the basis of management, planning and evaluation for education-based data. However, the information output by these systems is only as good as the available source data input to the system and the information processing tools employed by data analysts. High quality information systems make it possible to assess the current state of an education system and to undertake critical analysis at all levels of institutional aggregation in order to identify problems and propose solutions (UNESCO, 2006). Thus, EMIS place the emphasis on data-driven decision making, where the data provided to the system normally should come in different forms and at different levels of numerical and spatial aggregation (Breiter & Light, 2006). However, the success of EMIS, measured by the ability of planners and decision-makers to influence policy appropriately for the improvement of education systems, depends on the appropriateness and relevance of the input data and not just the availability of convenient or widely collected data.

Clearly, the accuracy and relevance of the knowledge of an education planner concerning the state of an education system is dependent largely on the availability and accuracy of information that describes all characteristics and aspects of the system. This information must be derived from complete and accurate data holdings that contain data which are relevant and useful to the education planner and which are updated regularly. In addition to accurate and current data, appropriate information technology tools are required for education planners to transform these education data into more usable information that can be transformed into knowledge about the current state of an education system. When the necessary data are available at the appropriate levels of aggregation, and when appropriate tools are available for the analysis of these data, planners are in principle more capable of evaluating whether education systems have met their objectives. They are also more capable of identifying problems (i.e., grade repetition and attrition) and their contributory factors (i.e., absenteeism) and of implementing meaningful policies that lead to improvements in the delivery and quality of education.

To date, however, education-based data collection has focussed mainly on the input and output components of the education model. For example, nine of the 18 core indicators proposed by the EFA companion framework, listed in Table 2.1, measure the input component of the education model. The 18 core indicators were chosen largely based on data availability (i.e., the EFA delegates took advantage of data that were already being collected due to mandates from other international organisations and aid agencies) and showed a clear bias towards a Western perspective of what good education systems should look like (UNESCO, 2000a). However, the input and output components essentially describe only the beginning and end states of a single cycle in an education system, and are thus not sufficient for an overall analysis of the quality of education provided at individual schools and within an education system overall. Since education is a continuous process complete evaluation also must include data and indicators which measure the process, outcome and context components. Otherwise, inaccurate conclusions about the state of the education system or the quality of education being delivered may result.

In the absence of complete data and information the possibility that education planners will come to inaccurate conclusions about the state of education systems is increased. For example, by focussing only on indicators that measure the input component of education systems planners and international aid organisations were able to state that substantial progress towards UPC had been made in many developing countries during the 1990s and early 2000s. However, after expanding the evaluation to include indicators (e.g., repetition and survival rates) representing other components of the education system (e.g., process, output, and outcome components), it became apparent that these gains had been offset to varying degrees by reductions in the internal efficiency of education systems and of the quality of education delivered. Thus, inaccurate conclusions about the improvement of education systems were derived from evaluations that used only a subset of the available and relevant data.

The EFA process also focussed primarily on evaluation at high levels such as nationally and super-national regionally aggregated indicators of education. In part, this was due to resource and capacity limitations and the desire to produce analyses that were comparable with other highly aggregated and commonly cited indicators such as the HDI. While this is useful for international or super-national regional comparisons (cf the results discussed in Chapter 2) it limits absolute assessments of the actual experience or quality of education at the local level. The high level of aggregation of the indicators typically used for evaluation of education systems does not allow the impact of specific effects of various contextual factors, such as socio-economic and environmental contexts to be assessed, and this cannot tell education planners very much about the experience of education and the quality of education delivered at the local level.

Thus, an understanding of spatial and numerical aggregation, as well as an understanding of the source microdata and the indicators derived from them, is critical to the design and use of information management systems for education-based data. For example, the survival ratio (an indicator of the output component of education systems) is defined as the ratio of students, out of a cohort, who successfully complete primary school within the prescribed number of years. This includes all children within a cohort and does not distinguish between children who do not complete primary education because they had no access to it in the first place and those who were enroled but failed to reach or complete the final primary grade (International Monetary Fund, 2006).

In super-national regions or nations where there are incomplete data, the survival ratio can be estimated by dividing the number of new entrants into primary grade one by the total number of students promoted out of grade one for the same year. This method provides only a gross estimation of the survival rate however and is not preferred. Clearly, education planners need to understand how this indicator is defined (and by extension, all indicators) and how data are collected to measure it in order to successfully implement policy changes based on the information provided by analysis of education systems on this indicator.

A further issue, noted above, is the highly aggregated level at which education systems are often evaluated. It is important to note that the routine planning and decision-making that takes place at the level of individual schools and classrooms is determined partly by the interaction between school administrators, teachers, students and parents. Thus, decisions made at the local level implicitly draw upon the qualitative and experiential knowledge of these stakeholders which is often difficult to measure and report in quantitative terms (Telem & Pinto, 2006). For these reasons the 18 core indicators are derived from only quantifiable disaggregate source data which can be collected at the classroom and school levels and easily aggregated to the jurisdictional boundaries of successive levels of the education infrastructure. Unfortunately, there is no specific framework in the EFA declaration or subsequent declarations to address the inherent value of examining these source microdata at the level of collection, or any mechanism to promote local level disaggregate evaluation or use of these data.

The Education Development Index (EDI) provides an excellent example of the limitations of evaluation using only aggregate data. The EDI, shown in Table 3.1, is used in the 2006 EFA monitoring report to classify countries according to their progress towards the six expanded DFA goals. The index assigns each country a score based on their progress towards each of these six goals. These scores are then combined and normalised to a range of zero to one, where a value of one represents the theoretical achievement of UPC. While this classification index is informative as a guide to measure relative successes of the implementation of EFA recommendations at the super-national regional level, it offers little practical information about the actual quality of education and experience of education delivered in these regions, nor can it offer any insight into the sub-national processes that result in individual countries performance on this index.

Region	<0.80	0.80 - 0.94	0.95 - 0.97	>0.98
Sub-Saharan Africa	16	7	1	0
Arab States	5	10	1	0
Central Asia	0	2	1	2
East Asia and the Pacific	3	7	2	1
South and West Asia	3	1	0	0
Latin America and the Caribbean	1	20	4	1
North America and Western Europe	0	1	9	8
Central and Eastern Europe	0	1	12	4
Total	**28**	**49**	**30**	**16**

Table 3.1 – National EDI scores by region
(Education for All Global Monitoring Report, 2006)

In order to influence education policy and decision-making effectively the sub-national source microdata upon which aggregated statistics such as the EDI are based also should be evaluated. The source microdata which are aggregated for national and super-national regional indices and evaluations, such as the EDI, are compiled from classroom, school and district level sources such as teachers and principals and the results from standardised surveys and tests. Clearly, the processes of education occur at the classroom level and the data collected at this level should be of the most value to education policymakers at all levels of the education system. While not all data collected at all levels can and should be analysed at each level of aggregation, there is often meaning to be gained from evaluating the data at the level which they were collected.

For example, some patterns in the data are discernable only at certain levels of aggregation. This suggests that some data can be aggregated without loss of meaning, however this does not imply that aggregation should be the rule. Overall, an analysis that is carried out at multiple levels of aggregation, and that takes advantage of the meaning and usage of the data at the most informative levels of aggregation will produce the best information to guide education planning and decision-making. Unfortunately, it appears that once data are aggregated and reported to donor nations (as required) and international organisations such as UNESCO, the disaggregated value that exist for these data are not capitalised further.

In fully implemented EMIS, evaluation of education data would be possible, in principle, at the least aggregated level where knowledge is as complete as possible. These EMIS would theoretically make the data collected accessible to all who can make use of them from parents to teachers up to the Minister of Education. However, the feasibility of implementing such an ideal EMIS is clearly limited by the economic constraints, technological capacity and administrative stability of nations. The costs in terms of both time and resources required to formalise indicator definitions, train teachers and principals in proper data collection, and ensure the accuracy and completeness of the data collected poses a significant obstacle. Despite these limitations and concerns, and due to the efforts of international organisations and the EFA process, the data that comprise national level indices such as the EDI are routinely collected (often informally) at the local level in most countries, and thus independent opportunities do exist to explore localised aspects of the education system.

Given the above concerns and challenges, it is clear that careful planning is required in the design of EMIS in order to ensure that all required data are collected and synthesised in a way that is useful for education policy planners and decision-makers. As previously noted, it is imperative to ensure that data collection is limited to relevant data only, so that extraneous or irrelevant data do not overwhelm the system. In the early stages of development feedback is required from all stakeholders in the education system in order to determine which events and processes within the education system should be measured. A clear understanding of what information is required of EMIS determines the appropriate source data that should be collected and input to these systems. Next, clear definitions of indicators must be designed and formal data collection methodologies must be implemented. Before these data can be entered into EMIS a database and software interface must be designed, or existing EMIS must be adopted and customised. Ideally, the result of this process are EMIS that create appropriate information from source data that are then used to generate new knowledge that can be used to develop policies for education improvement (Breiter & Light, 2006).

The differing information needs of stakeholders and participants at each administrative level of an education system are shown in Table 3.2. Data collection should take place initially at the level of the individual student, the classroom and the school. At each successively higher level of administration, the data collected are aggregated for evaluation purposes. Proper collection and reporting of individual test and performance scores, as well as classroom and school-level data, require mechanisms to ensure completeness and accuracy, even if performed only at the end of the school year. These mechanisms may range from basic peer-review of paper-based forms and surveys to more advanced digital methods directly integrated into EMIS (where teachers and others have access to computers).

Level	Stakeholders	Data Usage	Relevant Data
Classroom	Students Teachers	Collection	Disaggregated student data Grades and test scores Tracking of attendance
School	Principals Administrators	Collection and Evaluation	Aggregated longitudinal student data Grades and test scores Tracking of attendance Coordination of class scheduling Allocation of human resources Professional development Disaggregated finance and budgeting
Community	Parents Community Leaders	Evaluation	Disaggregated student data Aggregated administrative data
District	Superintendent Administrators	Evaluation	Aggregated longitudinal student data Aggregated longitudinal administrative data
Country	Ministers of Education International Aid Organisations	Evaluation	Aggregated administrative data Aggregated finance and budgeting data Aggregated performance data
Region	NGOs Political Leaders	Evaluation	Aggregated performance data Aggregated finance and budgeting data

Table 3.2 – Relevant data available in education systems
(Adapted from Breiter and Light, 2006)

For EMIS to be successful the responsibility to collect and report data must start with teachers, principals and in-school administrators. At the highest level of an education system, the Ministry of Education is responsible for the funding, implementation, and maintenance of annual (or semi-annual) censuses of school facilities, resources, and funding, as well as data collection incentives to ensure the proper reporting of indicators from very local levels up to the highest administrative levels. In addition, sub-national regional and local branches of the Ministry should take responsibility for their respective components of the overall education system. Education ministries must also work in conjunction with other government agencies to collect socio-economic contextual data to complement their school-based data holdings. Collectively, these education-based and contextual indicators describe and assess all five components of the education model. Table 3.3 sets out a number of high-level categories of indicators (for each component of the education model) that are relevant and appropriate for the development of EMIS.

Component	Indicator Categories	Methods/Tools of Measurement
Inputs	Student-teacher ratios	Student registration and staff employment records maintained by school-level administration
	Availability and quality of teaching materials	Inventories of teaching materials, their quality, and shortages recorded at classroom-level by teachers
	Total hours of instruction received by students in class	Work schedules and in-class lesson plans submitted by individual teachers
	Accessibility and quality of library and reading materials	Inventory of books in library, their condition, and their relevance (i.e., content, currency, accuracy) maintained by library staff
	Physical infrastructure and resources	Inventories of school infrastructure and resources, and their condition, collected by school administrative staff
	Capital and recurrent expenditures	Budgets reported by school-level administration
	Teacher skill levels	Teacher qualifications and years experience reported by school administration and/or human resources officials
Processes	Staff commitment	Promptness of teacher staff for regular hours recorded by administration, staff surveys of time spent by teachers on planning of lessons and time volunteered by teachers outside regular hours
	Attendance of students	Student attendance records kept by teachers in class
	Student time-on-task	Teacher lesson plans, teacher reports on individual students
	Usage of library materials	Records of books signed-out by students recorded by library staff
Outputs	Student promotion/graduation rates	Annual student census data reported by school administration
	Student progression to higher education levels (i.e., survival rate)	Annual student census data reported by school administration, including registration status of students after graduation for subsequent years, reported through the national ministry
	Student attitudinal changes over education cycle	Student assessments reported annually by teachers
	Student performance	Results of standardised tests, grades reported by teachers.
Outcomes	Increases in family earnings	National population census or employment survey data
	Housing conditions and ownership	National housing census, municipal housing records, or housing survey data
	Reduced crime rates	Police crime reports, community surveys
	Democratic participation	Percentage of voting-age population participating in elections
	Improved environmental and human health	National census or medical health surveys or insurance records
Context	Neighbourhood safety	Police crime reports, community surveys
	Health and nutrition of students	In-school surveys of student health and nutrition assessments
	Local housing conditions	National census, municipal housing records, or housing survey data
	Literacy and education levels of neighbourhoods and parents	National population census, community surveys
	Economic conditions of family and neighbourhood	National population census or employment survey data

Table 3.3 – Indicators that should be collected for the five-component education model
(Adapted from Leahy, 2005)

As noted previously, how data are translated into derived and calculated indicators that are useful for planners and decision-makers is critical to the success of EMIS. Disaggregated data can be subdivided by specific internal characteristics such as student age, grade and gender and made into multiple indicators representing these characteristics. Rate and frequency data can also be combined to produce calculated indicators that measure ratios or percentages such as the ratio of students per teacher, or the ratio of students per computer. Thus, indicators may range from summations of count data, to calculated rates or ratios of inter-dependant phenomena.

Defining an indicator begins with human-readable definitions such as "The number of classrooms in a school." The definition describes the source level of data collection, what the indicator measures, and how the indicator is measured. For instance, the example indicator defined above would be collected at the school level and would measure the total number of rooms in a school in which classes are conducted. The indicator would return a positively signed integer in the range [1 … n], with a theoretical upper limit relative to the size of the school building and the student population. Values outside of this range would be flagged as errors by error checking routines built into EMIS and by visual inspection of the data by database analysts. Thus, indicators defined in this way can be easily verified and checked for completeness and accuracy.

More complicated indicators, such as the survival ratio, are defined and calculated by combining multiple source data. Calculations of more complex indicators must take into account the quality and definition of these source data, especially where proxy or secondary measures are used in the absence of the most appropriate data for the indicator calculation. For example, in the absence of the best possible data, the survival ratio can be measured using the promotion rate from the final primary grade divided by the intake rate to primary grade one from the same year. In this case, the primary grade one data are used as a proxy for the actual size of the cohort upon entry into primary school mainly because these historical (in this context) data have not been recorded or converted into digital form, or are not available at the time of analysis. Clearly, this limits the use and interpretation of this indicator as a measure of the quality of education.

Well-established EMIS are common in developed countries. These systems for the most part consist of data obtained from standardised tests and school-level evaluations, but are also informed by smaller scale research projects that are usually issue driven (EQAO, 2007). The information output by these highly developed EMIS is usually made publicly available through Internet portals, or government publishing houses (normally aggregated at the school board level due to privacy concerns), and serves as a bureaucratic check and balance of accountability for resource consumption by an education ministry.

Examples of this approach can be seen in use worldwide, such as the Education Quality and Accountability Office (EQAO) of the Province of Ontario in Canada (EQAO, 2007). The EQAO publishes its requirements for data collection and assigns responsibility for the collection of indicator data to teachers, principals and other education planners. Accountability is therefore spread across many different levels, while still focussing on the day-to-day practitioners (teachers and principals) who have the most complete knowledge. Thus, effective education systems rely on effective EMIS to maintain accountability and support regular management and planning processes.

3.1.2 Adoption of Education Information Systems in Developing Countries

Developed countries have relatively well-established EMIS along with training and capacity-building opportunities to train education stakeholders in the use of these systems. This is not often the case in developing countries, however, or for countries with public education systems that are relatively immature or that are experiencing rapid growth. This is in part due to the limitations on technological capacity and economic resources that characterise developing countries. Without dedicated international aid and support, the poorest nations are unlikely to be able to divert their limited resources away from the core task of providing basic education resources, personnel and facilities, despite understanding the critical nature of monitoring and evaluating their education systems. Adding to this problem is the organisational structure of education ministries in developing countries. These ministries tend to be highly centralised which often leads to limited accountability, particularly at the local level. Given this, it is understandable that there is limited motivation to report on the performance of education systems at levels other than the national level, where this reporting is required relative to international obligations (UNESCO, 2005b).

Due in large part to the EFA process a number of governments in developing countries have been engaged recently in the process of decentralising administrative functions from the central level to geographically dispersed management units (UNESCO, 2005b). The requirement for decentralisation was imposed by various international organisations as a prerequisite for continued funding to these countries. This is generally a positive development, as corrupt bureaucrats in developing countries have often sought personal financial enhancement for services as monopoly providers, resulting in under-provision of services, especially for the poor and marginalised (Bardhan & Mookherjee, 2006). Decentralisation is also positive in the sense that local government is in principle more responsive to local and community needs. However, local government structures are often still subject to bureaucratic restraints and impositions and in some cases plagued by corruption. Moreover, decentralisation of managerial responsibility can only work if there is an accompanying decentralisation of resources and this rarely has occurred (Bardhan & Mookherjee, 2006). These concerns highlight the need for systems of evaluation, such as EMIS, to support accountability for spending and resource use within education systems.

In addition to economic constraints, education systems in developing countries often lack the necessary managerial direction and organisational capacity required to develop and maintain EMIS, let alone influence education policy in a positive sense using the data contained in these systems. UNESCO has recognised this and has developed a series of National Education Support Strategy (UNESS) documents that provide frameworks for donor organisations and countries working with developing countries to help identify their education needs and goals and to ensure that critical gaps in terms of expertise, capacities and financial resources are closed (UNESCO, 2007b). Central to this strategy is the development of a free and open source (FOSS) education management information system (OpenEMIS) which can be downloaded from the UNESCO web portal and adapted to suit the needs of individual education systems.

OpenEMIS was created to address the critical lack of capacity and expertise with respect to the establishment of data collection and monitoring and evaluation of education systems in developing countries. It was also developed to standardise the definition, collection, and reporting of the 18 core EFA indicators. While new indicators can be added to the OpenEMIS database, the package comes preloaded with definitions for the core indicators. The purpose of OpenEMIS is to facilitate the establishment of national information systems adapted to the needs of users at central, regional and local levels. Once adapted to the national context, the customised OpenEMIS allows:

(1) Improved data collection, processing, analysis and publication of information;

(2) Creation of easy-to-use interfaces for data entry and storage;

(3) Facilitation of access to and manipulation of data for the three prototypes of data users: application programmers, database administrators and end-users;

(4) Shaping the sharing of information in a multi-user environment; and

(5) Exchanging information with other systems, such as file management systems, spreadsheets, end-user interfaces (UNESCO, 2006).

Systems such as OpenEMIS can help to overcome some of the hurdles that developing countries face with respect to the implementation of EMIS. However, without the investment of international aid, the input of dedicated information technology professionals and support from government ministries the longer-term success of OpenEMIS in any developing country is suspect at best. In addition, the top-down approach inherent in the development of information systems in developing countries, such as

OpenEMIS, can short-circuit important discussions on best practices, accountability for data collection, and identification of relevant data that can or should be collected, which may vary greatly within and between countries (Unwin, 2008).

For example, given the core data that must be collected, and lacking any external incentive to collect new data or add new indicators to the system, OpenEMIS in general promotes institutionalisation of one perspective of what defines well-functioning education systems at the expense of all other perspectives. This is especially important for rural and vulnerable communities, where local environmental and/or socio-economic contexts have a large impact on the particular issues that are faced, and the particular qualitative and quantitative measures that can best describe these issues.

In addition, use of OpenEMIS does not alleviate, and may even exacerbate, costly and inefficient current practices of data collection in developing nations. These collection practices typically involve paper surveys distributed to and completed by day-to-day practitioners such as teachers and principals, for ultimate transfer to regional Ministry of Education offices. Due to cost and time constraints these surveys and reports are typically distributed only once a year, at the end of the school year. Analysis at any level of aggregation above the classroom can only begin once these paper surveys have been converted into digital form. This process may take months, and in some cases may continue on into the next school year. Thus, it may be several years before any real information or useful insight can be gained from data input to EMIS in this way. In addition, OpenEMIS, with its flexible, customisable database, and expanded capacity for more indicators may only serve to make these paper surveys longer and more difficult to complete and may eventually lead to surveys and reports not being converted to digital form at all, thus negating any benefits that may be realised from the implementation of these systems.

Additionally, there is a perceived lack of connection in developing countries, on the part of local level practitioners, between the day-to-day realities of education and the policies handed down from the national level. Local level practitioners often feel disconnected from the highest levels of education bureaucracy that receive and analyse the data that they often feel pressured or coerced to provide (Sharna, 2003). Without a strong reciprocal connection between the different levels of the education system, investing time and effort in mundane data collection and reporting activities is often considered to be a low priority by school-level staff. In addition, especially in developing countries where teachers are already overworked and underpaid, the imposition of extra duties is often seen as an unnecessary hardship. Consequently, the data that are collected to be transferred may be often incomplete or inaccurate because teachers and principals focus their time and effort on other tasks that are perceived to be more important in the day-to-day process of education.

Another source of inaccuracy is tied to the end of year data collection that dominates EMIS. Surveys and other data collection mechanisms imposed by education ministries usually coincide with the requirement for teachers to provide grades and a school report to their students (i.e., at the end of the school year). Teachers in developing countries are in some instances under pressure to achieve ministry-mandated pass rates or risk losing their pay and/or holiday time (Punch, 2004). Clearly, this provides teachers with a disincentive to report accurately, especially in rural areas where attendance is often low, and setting of grades is quite often arbitrary based on the teacher's perception of the ability and preparation of each student.

As Breiter (2006) notes, there is an inherent risk in this methodology, as it is quite easy for teachers to make slight adjustments to their grading scheme in order to satisfy ministry demands. This effectively lowers the overall quality of education because the Ministry, satisfied that minimally acceptable levels are being met, is not compelled to make changes to curricula, resources or materials in order to address poor performance. Finally, year-end collection of data ignores the continuous nature of education, and does not adequately address the process or context components of the education model. Seasons, weather and climate, as well as socio-economic cycles such as local market days, harvest periods and other family-based cycles affect student attendance, performance and preparedness for school. The effect of these cycles cannot be gleaned from a snapshot analysis at the final stage of the school year.

Thus, the goal of EMIS implementation should be to determine what data are to be collected, and to develop a strategy for the collection, maintenance and reporting of these data as well as their conversion into information and knowledge. This means striking a balance between information needs at each level and the cost of collection with respect to the overall goals of the education system (Carrizo, Sauvageot & Bella, 2003). Clearly, too much information can overwhelm an EMIS, while on the other hand by not collecting detailed data it is guaranteed that the EMIS will be of reduced utility, thus limiting the effectiveness of assessment that seeks to improve the quality of education at the local level. Finally, all EMIS must include data that measure all five components of the education system, as shown in Table 3.3, and that address issues identified at the local level. Thus, ready-built EMIS such as OpenEMIS must be highly adaptable and customisable in order to be successful.

3.2 The Role of Spatial Information in Education Planning

As noted previously, education systems are hierarchical in nature. In this vertically-integrated structure data and information flow from the local to the national level as mandated by national education ministries and international aid donors. However, a reciprocal flow of knowledge rarely is returned to the local level despite policy decisions which are often handed down often without an accompanying rationale or explanation. The upward flow of data and information is accompanied by successive aggregations of the source data. This aggregation is both numerical and spatial in nature and at each level of aggregation some of the inherent value of the data is lost.

The spatial aggregation refers to the loss of place within the data after they have been aggregated. For example, at more local levels, education planners, principals and even teachers are often aware of the issues and concerns at individual schools within their locale. They are able to recognise, even informally, patterns of activities or processes within their local system of schools and discern which schools are more efficient or offer a better quality of education. Education planners at the national level, on the other hand, cannot discern which areas, communities or schools within a particular region are responsible for lowering the values of an indicator for that region as a whole. This occurs because each reporting school, represented at the local level as a distinct point with a specific location within the geographic boundary of some large-scale political unit, becomes associated, in combination with all schools in the unit, with the entirety of the boundary when the data are reported and aggregated at the next level of administration.

While numerical aggregation figures prominently in much of the statistical reporting on education, especially by international agencies such as UNESCO, spatial aggregation does not. International agencies often seem unconcerned with the limitations of reporting at aggregate levels and often use aggregate data to evaluate long-term trends within education systems such as improvements in enrolment ratios over a period of a decade. While these organisations note the limitations of the numerical aggregation, they do not consider the location-based effects being masked by the implicit spatial aggregations that also occur within the data. Hence, spatial aggregation represents a hidden dimension of education systems that tends to be considered only at local levels.

When spatial aggregation is not considered, highly aggregated evaluation cannot account for the disparities between urban and rural populations; the differing access afforded to ethnic groups within multi-ethnic societies; the critical relationship between the socio-economic and environmental context of communities; and, education quality delivered at the school level. Policy planning and decision-making for the improvement of education systems can benefit significantly from an improved understanding of these complex factors and how their relationships vary across space. This is particularly important where responsibility and accountability are transferred to the local level through the process of decentralisation, as each locale has its own specific socio-economic and environmental context that differs from the next locale.

To account for this spatial variation in context and conditions, geographic information systems (GIS) are increasingly being deployed as one of the tools in school planning and education management. Hence, the following sections discuss the use of GIS for education planning. With respect to education systems, GIS provide the spatial link between the context component of the education model presented earlier (i.e., the home location of the student) and the other four components which take place at the school location. A general discussion of GIS technologies is followed by a review of the challenges and opportunities of implementing GIS in developing countries. The chapter concludes with a discussion on the importance of space and spatial analysis in education planning, and the challenges and opportunities for integrating GIS concepts and functions within EMIS designed to evaluate education quality in a developing country.

3.2.1 Geographic Information Systems in Education Planning

Information systems, such as OpenEMIS, store data in a simple relational database comprised of a series of related tables. In this schema the information is contained in separate tables and is related via unique identifier columns. Each row of any particular table in the database contains a set of related information about one real world feature or phenomenon (e.g., a school or a student). While relational database systems do not contain any particular geographic or mapping capability, they do reference data to discrete real world features, such as schools, city blocks, districts or regions which are inherently associated with either geographic locations or spatial boundaries. This provides the basis for extending EMIS and performing spatial analyses of the data they contain. The advantage of adding the geographic component to a generic information system is that by mapping these data, spatial patterns and trends can be observed that would not otherwise be apparent from a visual analysis of data that are contained in standard tabular format (Kerski, Linn & Gindele, 2005).

The term GIS refers to a broad range of spatial data management and analysis tools that facilitate managing spatially structured data to achieve map-based visualisation of patterns and easy query and analysis of education indicators. GIS use cartographic functionality to present visual displays of the geographic distribution of and relationship between phenomena (e.g., the presentation of roads and buildings and their spatial relationships within an urban environment). Various methods of cartographic representation can be used to emphasize changes across space, such as the density or distribution of objects of interest. Beyond map-based visualisations, the real benefit of GIS is the ability to perform spatial statistical analyses, as well as cluster analyses and assessments of spatial dependency. Without undertaking spatial analyses of data, it is difficult to gain any significant insight into the characteristics of the spatial relationships between objects of interest, particularly where many factors must be taken into account.

Developments in the information technology industry, especially the decline in price of software and hardware along with improvements in durability and portability of equipment, have lead to the rapid adoption of new technologies, such as GIS, in both the developed and developing world. While GIS are often seen as a tool for empowerment, like all information-based technologies, they can also be used to exploit interest groups, indigenous peoples and/or marginalised peoples (Kwaku Kyem, 2000). Arguments against the use of GIS note the hegemony over information exerted by these systems. For example, critics note that once the data are part of the GIS they can only be accessed, interpreted and analysed within the system, by the system (Pickles, 1991). Accordingly, the adoption of GIS has a tendency to confer power to a small group of stakeholders based on their technical expertise, affluence and status. This can marginalise those whose knowledge and experience are critical to appropriate use of the data and information contained in GIS (Curry, 1994).

In addition, while GIS are increasingly used to promote the interests of indigenous groups and local communities in the developing world, the appropriate conditions for adoption of these technologies generally do not exist. Adoption of new technologies is often at odds with the needs of communities and regions where high levels of illiteracy are coupled with traditional customs and practices (Kwaku Kyem, 2000). In the case of developing countries, the transfer and adoption of GIS technologies are dependent on associations with donor countries and on-going funding to support capacity building (Kwaku Kyem, 2000). This raises concerns over the ownership of information, dependence on donor nations and the loss of local-level knowledge to affect positive change for local communities.

Despite these concerns, GIS are used for a broad range of decision-making activities by governments, institutions, corporations, special interest groups and individuals. Decisions such as the allocation of resources, site selection for new facilities and the evaluation of facility performance and human resources are central to policy planning and decision-making. GIS are generally suited to handling these types of problems for education systems, as well as for understanding the contributory causes to processes and events that lower the quality of education. For example, policies regarding important process-based aspects of education systems such as absenteeism (e.g., policies regarding maximum instruction time that can be missed) are formed and implemented at the national level. Absenteeism, however, is a local level phenomenon whose causes are most clearly understood by day-to-day practitioners and stakeholders such as teachers, principals and parents. Given that absenteeism undermines the success of education systems through fostering of grade repetition and attrition it is clear that local understanding of the contributory causes to absenteeism should inform policy and recommendations, as well as aid in setting national and sub-national regional standards that are sensitive to local-level needs and conditions.

When used appropriately, GIS can inform and enhance the decision-making processes leading directly to policies and interventions that provide a sound information base for the monitoring and evaluation of the effect of changes in planning and decision-making on education quality. By providing education planners and managers with data analysis tools as well as maps of the spatial distribution of phenomena such as education quality and absenteeism rates at the school level it is possible to advance understanding of the factors that contribute to improvements of reductions in education quality at the local level and to develop clear policies and plans that bridge national goals and objectives with the realities of local contexts (Peters & Hall, 2004). For example, a spatial analysis may identify to education planners a cluster of schools in a rural area where high morbidity due to increased rates of infectious disease manifests as increased absenteeism at these schools. The education planner is then empowered to determine the reasons underlying the high morbidity and to suggest changes to local education policy to address the realities of the specific local context.

GIS are also increasingly being used in the fields of health and epidemiology. In Western countries GIS have been successfully employed to determine the impact of students home and school environments on their health. For example, proximity to pollution sources is highly correlated with student morbidity which results in increased absenteeism rates (Kwaku Kyem, 2000, Kulldorf, 2001). Early out-break detections for diseases such as malaria can also be identified by examining environmental and climatic conditions in combination with spatially-based incidence reports of infection (Kulldorf, 2001). At the level of the individual school or community absenteeism data may also be used to predetermine and/or predict when outbreaks of disease such as malaria, flu or seasonal illnesses will occur. In both of these examples, the use of GIS leads to policy recommendations and resource allocation (such as distribution of flu shots or malarial prophylaxis) to minimise or prevent the spread of these diseases, and thus to decrease overall morbidity among the student population and limit absenteeism. Thus, GIS have the potential to effect positive change in education systems when used appropriately.

3.2.2 Importance of Space in Analysis of Education Quality

As noted previously, spatial characteristics represent a hidden dimension in the evaluation of education systems. This is largely due to assessment of reported data at high levels of aggregation, such as at the district or regional level, which mask the spatial dimension inherent in local level education processes. Thus, policy planning and decision-making for improving the quality of education can benefit significantly from an improved understanding of how the processes of education are affected by the local and global level geographical relationships between and within schools as well as their surrounding context and how these relationships vary across space. This is applicable at all levels of the education system, but is particularly important where responsibility and accountability are transferred to the local level through decentralisation.

For example, the results of standardised tests administered at school have been successfully correlated to neighbourhood level spatially referenced socio-economic data in the United Kingdom (UK) (Bradford, 1991). This particular study revealed that the strongest explanatory factors predicting student achievement were, in order of significance, the individual intelligence of the student, the social class of the student's parents, the number of children in the student's family and the socio-economic characteristics of the residential environment. This outcome clearly demonstrates the importance of understanding the effect of space and location on policy-related planning and decision-making in education systems. Bradford further suggests that any two students with similar aptitude and family characteristics are likely to perform differently if the characteristics of the neighbourhoods they live in differ significantly. This clearly underscores the importance of the home environment, and thus the importance of the context component of education systems, as a predictor of a student's scholastic achievement.

A similar relationship was found in several North American studies. In these instances it was found that neighbourhood and community poverty profoundly affect children's physical health, cognitive and verbal abilities, educational attainment and social adjustment (Duncan, Brooks-Gunn, & Lawrence, 2003, Kerski, Linn, & Gindele, 2005). Thus, the spatial relationship between education and context is verified in several studies, and should be taken into consideration when evaluating the difference in quality of education delivered at individual schools within a particular study area (Flowerdew & Pearce, 2001). In addition, this effect is negatively correlated to the age of the student, suggesting that the effect of socio-economic context on a student's education achievement is most influential during the earliest and most critical years of schooling (McCulloch & Joshi, 1991). Thus, the youngest students are disproportionately affected by their environments, and this effect carries with them throughout their entire school career and throughout their entire life.

Thus, it is likely that there are circumstances that make the detection of socio-economic contextual effects on educational attainment more or less likely such as the typically homogeneous nature of Western communities. In both urban and rural areas, Western communities tend to be spatially segregated along socio-economic lines (Johnston, Wilson, & Burgess, 2006). Thus, the likelihood that a student's family characteristics match those of the families in the surrounding neighbourhood is likely to be quite high. In addition, it is quite likely that students attending a particular school typically live in neighbourhoods that are in close proximity to that school, especially in the case of lower socio-economic communities. Consequently, since a particular school is likely to draw the majority of its students from a single, socio-economically homogeneous community, the performance of individual schools will be variable across geographic space correlated to the socio-economic context of the school's surrounding community.

Even though a relationship between socio-economic context indicators and school performance may be evident, the causal relationship between these variables may be difficult to determine due to the overlapping effects of multiple contextual factors (Teddlie, Stringfield & Reynolds, 2000). For example, research has shown that there is a strong relationship between the mother's education attainment and the education achievement of her children at the primary school level (Behrman & King, 2000). However, it is important to note that the relationship is associative and not causal. The mother's lack of educational attainment does not cause the child's poor achievement, rather the correlation may be indicative of similar attitudes towards schooling, or similar cross-generational life experiences (such as the need to work) that limit the ability of the student to prepare for and take advantage of education processes.

Despite the clear need for understanding the spatial dimension of education systems, appropriate tools such as GIS to measure the effect of space and location have not been widely employed, especially in developing countries. In spatial terms, schools represented as points, and the catchment area from which they draw their student population, represented spatially as irregular polygons, define the initial geographic layers of a GIS, as well as the base reference for education data collected for analysis within spatially enabled EMIS. Integrating GIS and their spatial analysis capabilities with the school-based data and indicators stored in EMIS enables assessments of education quality respective to the goals of the education system. Unfortunately, despite some informative research correlating the impacts of spatial factors on education performance, this critical linkage between GIS and EMIS has not been extensively exploited in developed countries, where the need for this type of analysis is greatest. This implementation has been largely inhibited by sparse and/or poor quality data, lack of technological capacity and lack of sufficient infrastructure to support these technological solutions.

The immediate benefits of tightly coupling EMIS and GIS software include the ability to generate a visual display of the geographic distribution of various education system phenomena, at any level of aggregation using the basic mapping tools most GIS provide. Various methods of cartographic representation of data associated with spatial features can be used to highlight differences across geographic space. However, given the concerns noted in the previous section, how these data are collected, maintained, updated and most critically how they are accessed and actually used are all critical factors for the successful evaluation of education systems.

As noted previously, GIS have the power to both empower and marginalise. However, the marginalising effects of GIS and EMIS can be mitigated by ensuring democratic access by all stakeholders to the data contained in the GIS. With respect to education systems, this means ensuring teachers, principals, administrators, and high level officials all have equal opportunity to access and analyse education indicators and data. In addition, the data must be available to those outside the formal education system, such as parents, who wish to evaluate a particular school or a set of schools within a particular area of interest to them. Open and democratic access of this sort, although difficult to achieve in the case of a developing country with a large under-serviced rural population, is critical to open and transparent governance and accountability of education systems to the public.

3.2.3 Spatially-enabled EMIS and Access to Information

The rise of the information society, precipitated by the widespread adoption of ICTs in both developed and developing countries over the past ten to fifteen years has the potential to provide the essential infrastructure and capacity required to ensure the democratic access to data by stakeholders in all countries. However, the digital divide that currently separates technological *haves* from *have nots* suggests that any advantages ICTs may provide are preferentially benefiting education systems in developed countries, rather than assisting those in developing countries where they may have the greatest impacts.

The digital divide is most easily demonstrated by looking at the penetration rate of ICTs aggregated by region. Table 3.4, which measures Internet usage at the super-national regional level, clearly shows that the proportion of population connected to the Internet in the least developed regions of the world is disproportionately low (Internet World Stats, 2007). These same regions, however, are experiencing very high growth rates suggesting that they are catching up to the penetration rates of more developed regions. Latin America, for example, saw a 433.4% growth in Internet usage from 2000 to 2007.

This suggests that developing countries may be able to close, or at least reduce, the digital divide within the next decade. However, the aggregation in this table hides the disparity between urban and rural penetration rates which are more or less prevalent in all regions of the world. The vast majority of ICT penetration in developing countries is concentrated in urban areas, which further disenfranchises and disconnects remote rural populations, giving rise to a second digital divide within countries (as opposed to between countries and regions as discussed above).

The relevance of these trends for the implementation of EMIS is evidenced by the role that ICTs can play in providing access to data and sharing of information and knowledge among stakeholders in an education system. As discussed previously, the decision-making processes that take place throughout the planning and management of education systems rely on the availability of relevant data and the ability to process and analyse these data. ICTs, especially the Internet, support these processes in multiple ways, as they provide the infrastructure to disseminate education data. As well, ICTs facilitate flows of information and knowledge sharing between individuals and stakeholder groups, at multiple levels of aggregation, within education systems. In addition to the internal use of ICTs for the sharing of knowledge and the storage and analysis of data, the Internet supports accountability through the distribution of policy information and research reports and statistics to the public. In all these examples, delivery of information via the Internet minimises both the cost and time that would be incurred by other forms of distribution such as mailing or traditional television- and radio-based public advertising and awareness campaigns.

Region	Population (2007)	Proportion of Global Population	Internet Users (Total)	Internet Users (%)	Proportion of Global Internet Users	Internet User Growth Rate
Africa	933,448,292	14.20%	33,334,800	3.60%	3.00%	638.4%
Asia	3,712,527,624	56.50%	398,709,065	10.70%	35.80%	248.8%
Europe	809,624,686	12.30%	314,792,225	38.90%	28.30%	199.50%
Middle East	193,452,727	2.90%	19,424,700	10.00%	1.70%	491.40%
North America	334,538,018	5.10%	233,188,086	69.70%	20.90%	115.70%
LAC	556,606,627	8.50%	96,386,009	17.30%	8.70%	433.40%
Oceania / Australia	34,468,443	0.50%	18,439,541	53.50%	1.70%	142.00%
World Total	**6,574,666,417**	**100.00%**	**1,114,274,426**	**16.90%**	**100.00%**	**208.70%**

Table 3.4 – 2007 World Internet usage and population
(Internet World Stats, 2007)

In addition, ICT applications have the potential to enhance greatly as well as simplify the task of data collection for education information systems. The most common practice for data collection, as discussed previously, is for school-level staff to record information on standardised paper forms, which are submitted to higher level education authorities. Ostensibly, the data on these forms are then entered into digital databases by employees at regional or national ministry offices. This approach, in conjunction with the fact that data are often only reported at the end of the school year, significantly reduces the timeliness and usefulness of the data for analysis of the quality of education within the system.

Additionally, this data collection method can introduce problems of accuracy and completeness when data are mistyped, misread or when forms are lost.

Where possible, ICTs can be used to eliminate many of these obstacles by enabling teachers and school staff to enter data directly into digital forms on Internet-based applications running locally at schools or at decentralised branches of the Ministry of Education. The data can then be uploaded directly to an online central database, where verification and pre-processing can occur prior to analysis. While clearly advantageous, the implementation of this data collection methodology is limited in developing countries, especially outside of urban areas, due to the low overall rate of Internet usage and technological capacity. Rural schools often do not have access to continuous and uninterrupted power, and even where they do, the availability of computers, much less Internet-enabled computers is quite low. However, rural teachers, especially in Latin America, often live in urban centres and travel to their schools, meaning that there is an opportunity for these teachers to use a digital data entry system on a weekly or bi-weekly basis by using computers available to them either at home, at education ministry offices in urban centres or even at public Internet cafes.

Given these concerns and limitations, it is clear that widespread adoption of Internet-based data reporting is not possible in all areas of all countries at this time. However, in light of the rapid growth rate of Internet usage, it is sensible for developing countries to prepare for Internet-based data reporting and open Web-based access to education data where possible. Given that international processes such as EFA require annual reporting of data to international organisations, it is sensible for developing nations to adopt these technologies and allow them to disseminate out from highly connected areas as penetration continues into more and more previously 'remote' areas. In this way, the digital divide is narrowed at a rapid pace, and developing nations are able to take advantage of the expertise and technology of developed countries to improve their education systems.

3.3 Summary

The discussion in this chapter has identified the specific information needs of education systems, and of education policy planners and decision-makers. The chapter developed the case for the implementation of structured EMIS and identified how spatial information technologies, specifically GIS, can play an important role in education development by enhancing the collection, distribution and analysis of education data as well as by facilitating education planning and decision-making processes. The chapter concluded with a discussion of the challenges and opportunities for implementation of EMIS and the integration of GIS into education planning processes in developing nations. The following chapter places these issues within the context of Peru, and specifically within the Amazonian region of this country, where education is affected by a series of unique geographic and socio-economic contextual factors.

Chapter 4

Education in Peru

This chapter introduces Peru in general and the study area in the Department of Loreto, Province of Maynas. It provides insight into the unique characteristics of the study area that affect the delivery of a quality education and emphasizes how GIS can be used to aid education planners and decision-makers in developing countries such as Peru. First, a general background of Peru's geographical characteristics and contemporary history is provided, followed by the specific context of the study area. Next, the evolution of education planning and development is discussed and the current education system in Peru is explained. This is followed by a discussion of the current education and socio-economic data infrastructures in Peru, and the availability, relevance and usability of Peruvian data for the analysis of education quality at the various levels of spatial aggregation.

4.1 Education Planning in Peru

This section begins with a discussion of the recent social and political development in Peru, as well as a detailed look at the specific socio-economic context and characteristics of the study area in relation to the rest of the nation. This is followed by a discussion on the historical development of the education system in Peru focussing more closely on the most recent decades. This discussion highlights the significant changes in the economy and national policies that affect education and education policy that have occurred in the past twenty years. Finally, this section concludes with a detailed assessment of the current structure of the Peruvian education system and the quality of education being delivered both at the national level in general and within the study area in particular.

4.1.1 Background

Peru is the world's 20th largest country, comparable in size to the US state of Alaska. It straddles the equator on the Pacific coast of South America, sharing borders with Ecuador and Colombia to the north, Brazil and Bolivia to the east and Chile to the south. Peru is divided along a north to south axis by the northern reaches of the Andes, with the highest peaks occurring in the *Cordillera Blanca* north of the capital city Lima. The southern Andes region is home to the world renowned *Lago Titicaca*, the world's highest navigable waters. To the east of the Andes, the highlands descend rapidly into the tropical jungles of the Amazon Rainforest. On the western flanks of the Andes in the south lies the *Altiplano*, a high arid desert plateau, which forms the northern most reaches of the Atacama Desert, known for its status as the driest place on the planet. The western coast, home to the majority of the population is largely arid desert giving way to more temperate arable coastal lowlands in the north (Peru Tourism Bureau, 2007).

The population of Peru, estimated at just over 28 million with a modest growth rate of 1.289%, is multi-ethnic and diverse (CIA, 2007). Amerindians (indigenous pre-Columbian natives) made up largely of the Quechua and Aymara peoples according to the 2004 household survey conducted by the INEI make up 35% of the total population. The majority of the population however are *Mestizo*, an open-ended term which encompasses diverse peoples of mixed Amerindian and European ancestry who do not self-identify as either Amerindian or European. Despite being a predominantly Spanish-speaking nation, language and ethnicity are strongly divided along geographical and socio-economic lines. Traditionally the Andes have formed a cultural as well as a geographical barrier between the largely *Mestizo* urban centres along the coast and the Amerindian population of the highlands and tropical rainforests. However, with increasing economic development, access to employment, intermarriage, and large-scale migration from rural to urban areas, a more homogeneous national culture has developed (CIA, 2007).

Peru's economy is largely resource-based and dependant on the large deposits of oil, natural gas and minerals found throughout the Andean region. The coastal waters are also excellent fishing grounds. Peru's dependence on natural resources, however, has subjected the economy to fluctuations in world prices, causing a lack of stable physical and economic infrastructure that has deterred foreign trade and investment. Thus, while the Peruvian economy grew by more than four percent per year during the period of 2002-2006, underemployment and poverty have stayed persistently high, especially in the rural and peri-urban areas of the country (CIA, 2007). Peri-urban areas are areas of lower density housing and infrastructure development located at the periphery of urban areas that still retain some features of rurality.

Another deterrent to investment and a persistent problem is the rural population's dependence on the coca trade. Until 1996 Peru was the world's largest coca leaf producer. Although it now lags far behind neighbouring Colombia, it is still the second largest global coca producer. Despite this drop in ranking, cultivation of coca leaf in Peru still rose 25% in 2005 to an estimated total of 34,000 hectares with much of this coca leaf shipped to neighbouring Colombia for processing into cocaine (CIA, 2007).

Peru's political history is volatile, including a recent period of military rule and the imposition of martial law from 1968 to 1980. During this period the country experienced significant social and economic problems linked to inflation, and a lack of job opportunities, as well as the rise of a violent insurgency by guerrilla movements such as the *Sendero Luminoso* (Shining Path) and the Tupac Amaru Revolutionary Movement (MRTA).

Peru appeared to be on the road to recovery beginning with the landslide election of President Alberto Fujimori in 1990, however, an economic downturn in the late 1990s, increasing authoritarian governance and widespread corruption led to Fujimori's abrupt dismissal from office in 2000. In 2001, after a year of rule under a transitional government, Alejandro Toledo was elected to the Presidency. Toledo's popularity was not long-lasting due to widespread concerns over corruption. In 2006 he was replaced by Peru's current president, Alan García, who had served one previous term as president from 1985 to 1990.

Notably, Peru lags behind other Latin American countries in literacy (two percent below the regional average), access to improved water (eight percent below the regional average), as well as infant mortality and life expectancy (World Bank, 2006). Despite lagging in the region, the statistics indicate that Peru is outperforming countries from other developing regions with similar development profiles on the key socio-economic indicators mentioned above (UNESCO, 2007a). This may be in part due to the constantly expanding resource sector which has propped up the economy since the end of the period of military rule. Figure 4.1 clearly demonstrates the dramatic turnaround in economic growth since the end of military rule, showing the growth rate of gross domestic product (GDP) and GDP per capita over the last 20 years.

The Department of Loreto has been fortunate in some respects, in spite of Peru's turbulent political history. Thanks to its geographic location in the extreme northeast of the country and its largely Amerindian population, it has largely been removed from the political and social turmoil that has plagued the more heavily populated areas of the country. In particular Loreto was largely spared the ravages of the *Sendero Luminoso* whose terrorist activities were concentrated in Lima and the rural areas surrounding the city of Ayacucho. The down side has been a sense of isolation and disenfranchisement from participation in the overall development of Peru, which has lead to recurring popular support for Ollanta Humala's nationalist indigenous movement which advocates regional autonomy by any means, including by force if necessary (Power and Internet News Report, 2007).

As well, there is a large disparity in childhood health and wellbeing in Peru, divided along largely rural and urban lines. While Peru's recent prosperity has lead to an overall reduction in the rate of childhood morbidity (as measured from 1999 to 2005) there was still a large gap, as shown in Figure 4.2, between rural and urban morbidity in 2004 for children in the age six to nine range. This disparity is evident even in the most developed area of the country, Lima and its surrounding environs. Childhood morbidity for the urban area of Lima is 6.4% compared to 14.7% for the surrounding peri-urban and rural population (*Ministerio de Educación*, 2007b).

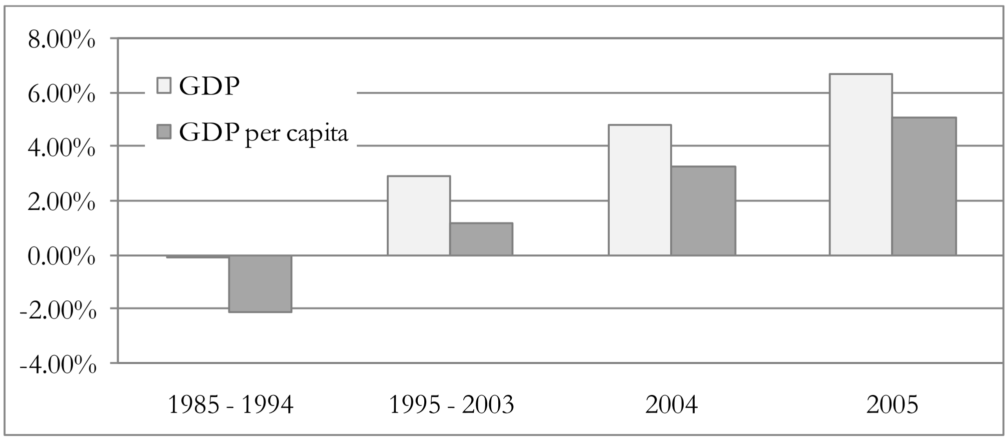


Figure 4.1 – Growth of GDP and GDP per capita in Peru
(World Bank, 2006)

Less than one third of the population of the Department of Loreto lives within the urban limits of the city of Iquitos, the regional capital. Virtually the entire department is dominated by the tropical rainforests of the Amazon basin, making Iquitos an urban island accessible only by air or water. The only other urban area accessible by road from Iquitos is Nauta, the second largest population centre, with a population of only 15,000 (Vittor, Gilman, Tielsch, & Glass, 2006). Iquitos, with a much larger population of around 367,000 is the economic and commercial centre of the region (Go2Peru, 2000). Iquitos was established in 1864 yet it remained quite small and remote until the rubber boom of 1880-1912 when the population jumped from 1,500 to over 20,000.

The local economy collapsed almost as quickly as it grew following the decline of the Latin American rubber industry and the crash of rubber prices in 1932. Despite the recent interest in the oil and natural gas reserves throughout the Amazon Basin, little local labour has been employed and few local economic benefits have been realised. Supporters of the local community suggest that government policy, set in Lima and controlled by largely extra-national corporations, has allowed the area to be exploited and its resources extracted without benefit to the local economy.

Despite its remoteness and resource-based economy, significant improvements have been made in public education in Peru in general and Loreto in particular in the form of increased spending and decentralisation of the education system. These changes have been made possible by the relative stability of the Peruvian economy during the last several years (World Bank, 2001). However, as of 2002, approximately 60% of Peruvian children less than 18 years of age continue to live in poverty (20% in extreme poverty) and five percent of children under the age of five suffer from malnourishment (U.S. Department of State, 2003). Infant mortality rates also rose marginally from 33/1000 in 2000 to 34.1/1000 in 2002. Of the rural children who live in poverty, only 50% enrol in secondary education, compared to 75% of those from more urban and more affluent socio-economic circumstances within the country. Given this general situation, there are clearly challenges within Peru that significantly affect the performance of its national education system, as well as specific challenges for the rural areas of the country.

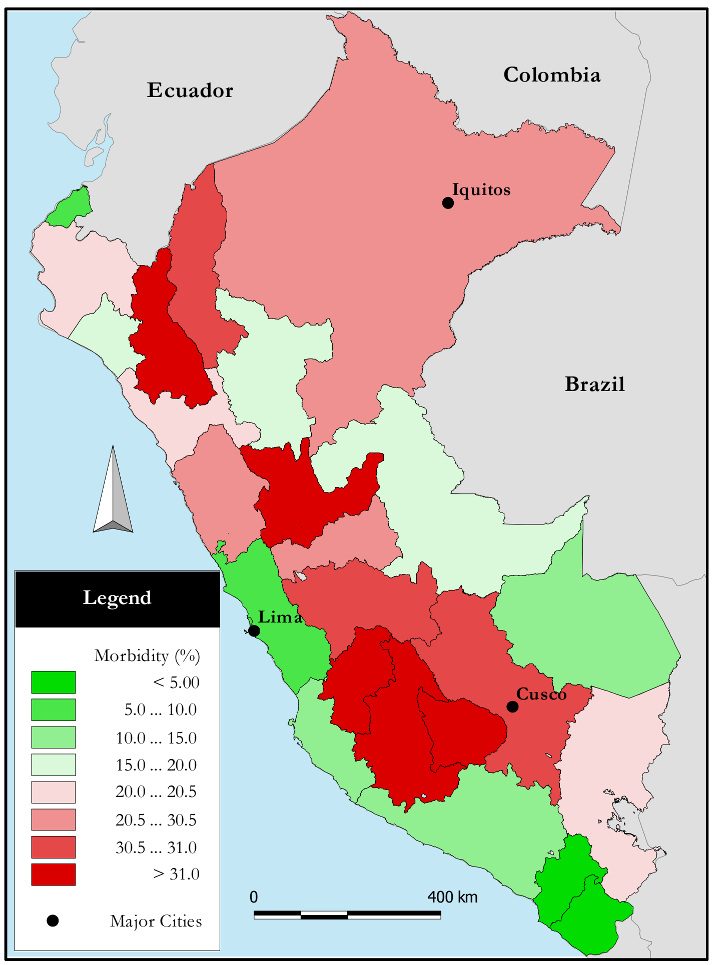


Figure 4.2 – Childhood morbidity rate (2004)
(Ministerio de Educación, 2004)

4.1.2 History of Education Planning in Peru

A national education authority was created in Peru in 1825, several years after independence from Spain in 1821. The initial authority was a colonial-style institution responsible for largely Christian-based education limited to elite classes, reflecting the colonial structure of society at the time (*Ministerio de Educación*, 2007a). This authority was replaced by the Ministry of Education (MINEDU) in 1956 as a result of the *Plan de Educación Nacional* passed in 1950. The plan revolutionised education in Peru not only by creating a central ministry, but also by mandating the opening of hundreds of schools, and laying the groundwork for continued public investment in a nationally-structured education system (*Ministerio de Educación*, 2007a). However, the national education system has undergone significant changes since the establishment of the MINEDU.

Throughout the 1950s there was an increasing awareness of the role of education as a transmitter of cultural wealth, values and knowledge. This was reflected in the separation of the institution for Justice, Worship and Education into independent authorities which led to the establishment of the Ministry of Education (*Ministerio de Educación*, 2007a). In its first year, the MINEDU conducted a student and infrastructure survey to assess the state of the education system in Peru. This was the first of many MINEDU assessments that have attempted to track the changes of the rapidly expanding system. During the 1950s the number of primary schools rose by 6,500 and the number of teachers nearly doubled in response to the rapid urbanisation of coastal and highland cities (King & Bellow, 1989).

From the inception of the MINEDU to the beginning of military rule in 1968, primary, secondary and tertiary enrolments increased by 78%, 166% and 281% respectively largely due to very high birth rates across the country in conjunction with the rapid urbanisation mentioned previously (these high birth rates would continue to tax the education system until the 1990s). This placed strains on resources and infrastructure as well as the ability of the education system to deliver quality education, evidenced by falling matriculation rates at the higher levels of education. For example, the proportion of students continuing on to secondary education remained below 11% during this entire period (*Organización de Estados Iboamericanos*, 2006), suggesting that the remaining 89% of primary school students either failed to complete the primary level of education, failed to complete by an age suitable for enrolment in secondary education or saw no benefit in the pursuit of post-primary education.

The imposition of military rule altered radically the role of education in Peruvian society. Under the military regime of Juan Velasco education was considered to be a tool that could be used to strengthen and support the regime's broad political revolutionary goals. Indeed, Velasco considered the success of reforms in the education system central to the success of all other structural reforms (Haddad, 2000). The main objective of the education policies of the junta was to remodel the education system based on far left social ideals focussed on individual citizens for the development of a free, fair and stable society (Haddad, 2000). The role and agenda of the education system were changed to realise these goals. Specifically, the structure of the education system was replaced with three new levels, namely the initial, basic and superior levels. These levels did not correspond to the traditional primary, secondary, tertiary levels. The basic level included primary, middle and high school cycles of four, two and three years respectively. The intended focus of the basic level was psychological development, and basic learning. Education at the higher two levels focussed on labour-based training, and was broken into four streams, specifically regular, labour, special, and professional (*Organización de Estados Iboamericanos*, 2006).

Despite its egalitarian ideals, the overall effect of the military reforms was to weaken the Peruvian economy. The education system was particularly affected. By 1980, its share of public funding had fallen to 13%, representing 3.12% of GDP. This, in conjunction with the rapid increase in teacher salaries enacted in the regime's latter years under Belaunde (Velasco's successor), placed a drain on dwindling public resources. It also became apparent at this time that disparities in educational services between urban and rural areas and the quality and efficiency of schools had not improved during the military regime's years in power. An assessment of the education system in the early 1980s showed that most rural schools still only offered the first three grades of primary education, and secondary schools were virtually non-existent in many rural areas. About one-half of all schools, mostly in rural areas, lacked equipment, teaching materials and other critical resources such as desks (King & Bellow, 1989).

The transition to democratic rule beginning in 1980 posed significant challenges due to systemic political, social and economic instability. This instability peaked in the late 1980s with the fiscal deficit reaching 10% of GDP in 1988, increasing annual hyperinflation that reached 7000% in 1990, and the rising militant insurgency of the *Sendero Luminoso* and the MRTA. In addition, public spending on education fell consistently throughout the 1980s, falling to a low of 2.2% of GDP in 1988, representing a 60% cut in education funding from the previous year (World Bank, 2001).

Despite these challenges and limitations, restructuring of the education system began immediately with the passing of the General Education Law in 1980. The education system was divided into two streams, *escolarizada* and *no escolarizada* (effectively translated as formal and informal). Informal education allowed for learning through other educational agents such as family, community and local religious or political organisations. Recognising these forms of education, and allowing school age children to pursue education outside of the formal system, relieved some of the burden on the resources of the latter. This informal system, while necessary due to economic conditions, reintroduced unequal distribution in the quality and quantity of education throughout the nation (World Bank, 2001). The education system also reverted back into the more traditional initial, primary, secondary and tertiary levels, with the primary level offered for minors, adults, special needs, occupational training and distance education.

Beginning in 1990, with the Fujimori government, major structural reforms and macro-economic management changes were introduced to stabilise the social, political and economic problems facing the nation. By 1994 the most radical elements of the *Sendero Luminoso* and the MRTA were brought under control, ending years of terrorism, unrest and lack of confidence in government and leadership. In addition, despite the economic downturn precipitated by the Asian economic crises, a balanced national budget was achieved with national savings reaching 4.4% of GDP by 1997. The focus on education reform during this period was on economic restructuring, containing public expenses, encouraging school privatisation, and decentralisation by delegating responsibility to individual regional authorities.

Consequently, employment at the central administrative level within the MINEDU was reduced by 72% and hiring for pensionable positions, such as teachers, principals and administrators was frozen. Vacant or new positions were filled with consultants or contract personnel, at a much lower cost to the government (World Bank, 2001). These cuts were augmented by two substantial investments from the World Bank, totalling US$310.5 million, one aimed at urban school rehabilitation and one aimed at rural primary school access.

In 1993 a new constitution was enacted in Peru. This constitution dramatically altered the political structure of the country. With respect to the education system, a new law, *Nuevo Reglamento de Organización y Funciones del Ministerio*, was passed to coincide with the requirements of the new constitution. Most significantly, free and compulsory education was extended to include the Peruvian versions of kindergarten and secondary education. However, the change was not implemented, largely due to cost constraints, until 1997 when an amendment to the law proposed to revise the education system by changing the duration of each level of education.

The emphasis of the schooling system was shifted towards the early years of education, with a focus on developing the capacity for learning. The proposed changes eliminated the non-compulsory, financially prohibitive, pre-school system, established a lengthened primary school cycle (including kindergarten), and shortened the secondary education cycle. The shortened secondary cycle was augmented by a free but non-compulsory program (*bachillerato*), designed to support the transition to tertiary levels of education. The overall effect of the proposal was to increase the compulsory time spent in school (in years) for all school age children. Table 4.1 provides an overview of the proposed changes in comparison to the existing structure in 1997.

Pre-1997		Post-1997		Objective of Change
Student Ages	**Existing Structure**	**Student Ages**	**Proposed Structure**	
3-5	Non-universal initial education (kindergarten)	5	1 year of universal initial education	Facilitate the articulation between initial and primary education to improve the efficiency of the system
6-11	6 years of universal primary education of uneven quality (primary)	6-11	Duration of primary school unchanged, but emphasis placed on improving quality	Develop the capacity for learning
12-16	5 years of secondary education that has uneven access between rural and urban areas (secondary)	12-15	4 years of universal free secondary education	Guarantee free access and the use of distance education for rural areas to extend coverage. 1 year of preschool, 6 years of primary, plus 4 years of secondary education will provide 11 years of universal basic education
		16-17	2 years of *bachillerato*, a non-compulsory, free education	Preparation for work and for tertiary education. Certification at end of *bachillerato*.
17+	Tertiary education	18+	Tertiary education	Remains unchanged

Table 4.1 – Comparison of education structures before and after 1997
(Adapted from the World Bank, 2001)

The new law and its subsequent amendment did not propose or require increases in education funding and this had the consequence of fewer resources per unit for an expanding education system. Fujimori's government handled this resource shortage by encouraging the establishment of private schools through legislative means. This legislation, combined with retrenchment of education personnel, led to the rapid development of private schools. The private system met the demand of parents who were weary of frequent closing of public schools due to strikes, who considered the quality of public education unsatisfactory, and who could afford to send their children to a private school. From 1990 to 1997 enrolment in private schools outpaced enrolment in public schools at all levels of education, despite absolute enrolment levels in public education expanding by six to seven times over the same period (World Bank, 2001).

The benefits of the private education system were not equally distributed. For example, urban areas accounted for 39% of net enrolment in private primary schools. By contrast, private education was virtually unavailable in rural areas of Peru, where less than 0.5% of all primary students were enroled in private schools by 1997. In addition, students from the wealthiest quintile in rural areas, while having the highest enrolment in public schools (98% net enrolment vs. 85% net enrolment for the least wealthy quintile), had the lowest enrolment in private institutions (0% vs. 0.1%; up to 2% for the middle quintiles). In addition, the lowest socio-economic brackets contributed only 15% of total enrolment to the private system for urban and rural areas combined (World Bank, 2001). Thus, the supposed promise of quality and accessibility of the private school system was only available to the wealthiest income groups living in urban centres. Consequently, the public system remained the primary provider of education of all students from families of low socio-economic status, and almost exclusively to all rural students (World Bank, 2001).

Despite high initial popularity and confidence, Fujimori's government ended in ignominy in 2000 with the President faxing in his resignation from exile in Japan. The later years of his presidency were plagued by concerns over scandal, criticism over human rights abuses, and growing national instability due to the undermining of the political system by drug cartels. Fujimori also left the education system in disarray. While educational attainment was relatively high in Peru there was still very unequal distribution of access to education, as well as education performance and results between urban and rural areas. While primary school expansion under Fujimori had produced near universal access to full primary education in urban areas, largely thanks to the private system of education, primary and secondary education remained inaccessible to the majority of rural youth. For example, in 1997 in rural areas only 24% of the 16 to 18 year old cohort had competed secondary education, compared to 64% in urban areas (World Bank, 2001). Significantly, quality of education, as measured by student's scores on international standardised tests, was at the low end in Latin America and even higher socio-economic students scored much lower than their counterparts in other countries within the region (Independent Evaluation Group, 2005).

While Peru did not formally adopt EFA goals in national policy until after the Dakar conference in 2000, the 1990 World Conference on Education for All (WCEFA) likely played a role in the 1993 education system reforms, such as the expansion of free and compulsory education. The World Bank (2001) describes these reforms as first generation reforms primarily focussing on the containment of expenses and mobilisation of private resources. The second generation reforms, occurring in the early 2000s, lead to the establishment of the current education system, which focuses on the outstanding issues of inequality, quality improvement, continued expansion and internal institutional problems. The next section discusses these second generation reforms, and their impact, and describes the current organisational structure of the Peruvian education system.

4.1.3 Current Education System in Peru

The process of decentralisation of the MINEDU began in 2002. The MINEDU was restructured at this time around three levels of government, namely national, regional and local. This restructuring was initiated under Constitutional Reform Act no. 27680 and Decentralisation of the Basic Organisations Act no. 27783, both dating from 2002 (UNESCO, 2005a). This was followed in 2003 with the passing of a new education law that instituted decentralisation and set out the processes by which the decentralisation would occur, including sections on funding, resources and infrastructure. The law focussed specifically on issues of local management, improved education quality, democratic practices in schools and communities and contained a section specifically on rural challenges for the newly decentralised ministry (USAID, 2005).

The purpose of decentralisation was to promote greater participation by citizens, to increase efficiency and transparency and to reduce social and economic inequalities between regions. More generally, the decentralisation was a direct result of the influence of the EFA process and the desire of the Peruvian government to benefit from these goals (UNESCO, 2005a). The structure of the MINEDU, which has not changed in recent years, is shown in Figure 4.3. In the newly decentralised MINEDU, the Ministry retained the overall responsibility for setting broad education policy for primary, secondary, and tertiary education at the national level. The MINEDU is also charged with the mission of developing the character of the individual, improving the quality of life, and facilitating social development in Peru through promotion of culture, science and technology, physical education, and pursuit of excellence (Independent Evaluation Group, 2005).

Funding for the decentralised structure of the Ministry comes from the top down, with resources directed from the central government directly to the regional administrative authorities. The funding is then sub-divided by these authorities and distributed among their subordinate institutions according to perceived needs and opportunities (Independent Evaluation Group, 2005).

Management of specific functions or areas of responsibility within the MINEDU at the national level are assigned to various offices. Offices such as the National Education Council and the National Council of Democratisation of Books and Reading Development function as the supervisory units for the MINEDU, promote the goals and purpose of the MINEDU by cooperating with other institutions in the public and private sector and act as the primary mechanism through which plans and budgets must be approved. The latter of these councils has the more specific purpose of promoting Peruvian authors and their literature within Peru and internationally, while the former is responsible for overseeing the operations of the MINEDU and the education system itself. The general administrative operations of the MINEDU are maintained by the Institutional Control Office (ICO), with direct input from general secretary of the Ministry. The office of Strategic Planning (SP) is responsible for supporting education policy and decision-making by conducting research and publishing reports.

The Office of Strategic Planning is also directly responsible for the measurement of education quality. Assessment of the education system is divided between two units, the Education Statistics Unit (ESU) and the Unit of Education Quality Measurement (UMC). The ESU maintains the entire census and survey data collected by the MINEDU, and publishes these data via the Education Quality Statistics (ESCALE) web portal. The goal of the UMC is to establish ongoing monitoring and assessment of education quality. Finally, the UMC is also responsible for publishing reports to the public, making recommendations, and supporting the development of plans of action.

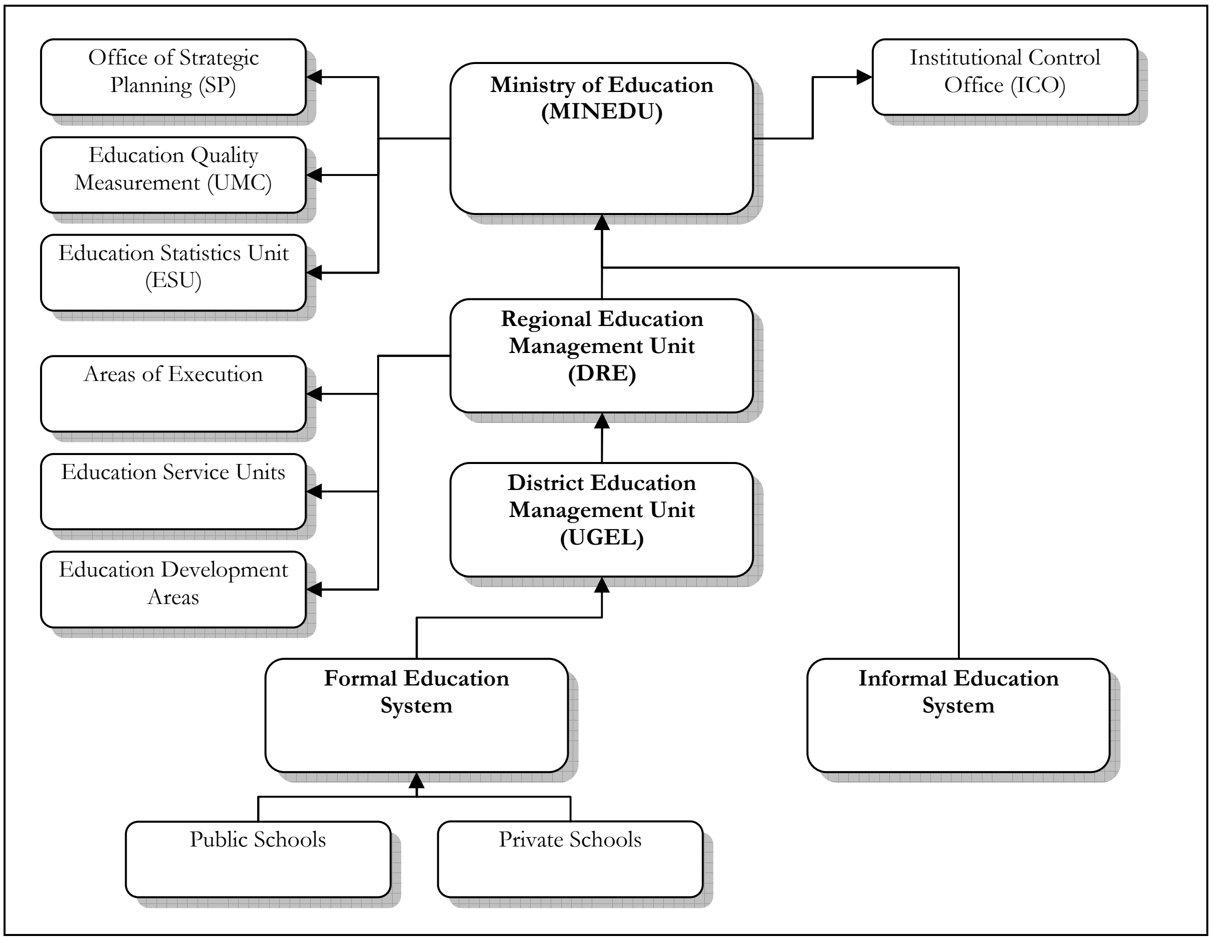


Figure 4.3 – Current structure of the MINEDU
(Adapted from World Bank, 2001)

The responsibility for the actual provision of educational services from kindergarten to *bachillerato* is delegated to the regional level under the control of the Regional Directorate (*Dirección Regional de Educación*, DRE). The DRE administrative boundaries correspond with the boundaries of the other regional level Ministries. Directors for each DRE are appointed by the Minister of Education with the approval of regional administrations. However, sub-regional directorates no longer exist outside of the

DREs as recent restructuring has moved towards simplifying and streamlining the management levels of the Peruvian education system. Directly below the level of the DREs are the local education management units (*Unidade de Gestión Educativa Local*, UGELs). These management units correspond to the provincial level of administration, although their administrative borders are not directly coincident. UGELs cover slightly smaller areas than provinces (there are 207 UGELS versus 194 provinces), due to the disaggregation of densely populated provinces, such as the provinces surrounding Lima and Cusco, into several UGELs to provide better education delivery.

Public and private schools, as well as the informal education networks, fall under the authority of this lowest administrative Ministry level. Education networks include community groups participating in education development, or in some cases external agencies managing groups of schools funded by the MINEDU. An example of the latter sort of network would be the international Jesuit organisation's network of schools named *Fe y Alegría*, which currently manages over 200 schools at both the primary and secondary levels, 98 of which are dedicated to the delivery of rural education in the impoverished areas of Peru such as the rural area outside of Iquitos (*Fe Y Alegría*, 2002). While funded by, and accountable to, the management units within the MINEDU, these education network schools are managed separately by the sponsoring organisation and rely upon local administrative networks and the local communities for support, supplemental funding, and for staff (*Fe y Alegría* schools are staffed and run mostly by Catholic nuns).

Education processes take place at individual schools which represent the lowest level of management within the MINEDU. What actually takes place in a specific school is determined by the policies and financing managed through all the higher levels of institutional aggregation within the education system. While it is appropriate for planning and policy to be set at the national and regional level, contextual factors that affect education inputs, processes, outputs and outcomes are variable at the local scale. Planning policies that do not take these local effects into consideration are unlikely to have any positive impact on the overall quality of education delivered at the school level. This thinking underlies the need for decentralisation of management structures within the education system, and underscores the need for strong information sharing between all levels of the education system, as discussed in the previous chapter.

4.1.4 Education Quality in Peru

Peru has been able to achieve modest advances in education quality despite the broad socio-economic challenges discussed previously. Indicators of progress towards EFA, such as the primary gross enrolment ratio (GER) declined from 1990 to 2004 to a value of 113.8%. Despite this decline the GER is still above the optimal value of 100% suggesting that the system is still attracting over-aged entrants and previously un-enroled students of the appropriate age cohort. While the GER is slightly below the regional average of 117.9% it is on par with countries of similar socio-economic profiles (World Bank, 2006). Significantly, the GER for females and males is equal, and the gender parity for many of the education indicators discussed in Chapter 2 (GER, NER, AIR, and literacy) is at or about the optimal value of 1.0, signalling that Peru has largely overcome gender disparity issues, a significant accomplishment on the world stage (UNESCO, 2007a). In addition the GER for secondary education, in the post 1997 education hierarchy, has continued to improve suggesting that the primary school system has increased internal efficiency and is preparing a greater number of students for continued educational achievement.

The net enrolment ratio (NER) increased from 87.5% in 1990 to 97.1% in 2004. While this represents a significant improvement in the input component of the Peruvian education system, there were still an estimated 14,606 primary-age students out of school in 2004, over 12,000 of whom were males (World Bank, 2004a). This might suggest a prevalence of youth labour, especially in the upper primary cohort. It is also important to note that these high GER and NER values may be masking some other important trends in the quality of education. For instance, from 1999 to 2004 the net intake ratio (NIR) was largely unchanged, remaining around 97% (UNESCO, 2007a). While the value is relatively high, the stagnation of this indicator's value may be a sign of school avoidance or a lack of confidence in the education system on the part of parents. Unfortunately, due to national level indicator aggregation it is impossible to compare urban and rural NIR values to determine if the national average of 97% is representative of the NIR for different areas of the country (such as the Andean area versus the Coastal area, or more generally urban versus rural areas). It is certainly possible that increases of NIR in the more prosperous urban departments have been offset by decreases in rural areas.

One final indicator of interest at the national level is the rate of repetition. Repetition, which measures the process component, is not included in the NIR calculation, and thus must be evaluated separately. At the national level the repetition rate remained above the regional average despite declining steadily from 1999 to 2003 (the last year for which values for this indicator are available). Of particular interest is a disaggregation of the repetition rate by grade. As shown in Figure 4.4, the repetition rate steadily declines from the second primary grade through to the final grade of primary school. This is generally a positive trend, although it is difficult to determine from national level data whether the decline in repetition is due to increased quality of education, or desertion from the education system by underachieving and/or underperforming students who tend to over-contribute to indicators such as grade repetition. This indicator, coupled with an increasing survival rate (up to 84.1% in 2003), a declining teacher to pupil ratio (down to 22.2 pupils per teacher in 2004), and an increase in trained professional teachers (as discussed previously) clearly shows that the Peruvian education system continues to make some improvement in education quality when evaluated at the national level.

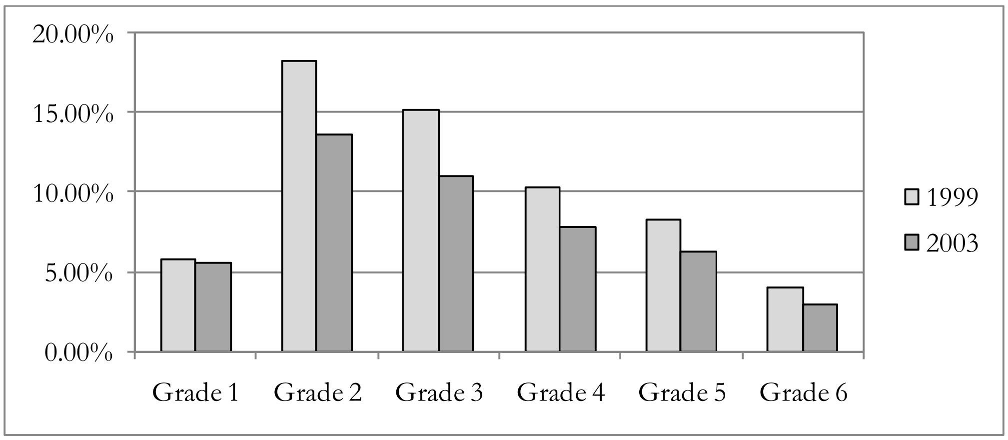


Figure 4.4 – National repetition rate by primary grade in Peru (UNESCO, 2007)

There is a noticeable difference, however, in the socio-economic conditions between urban and rural areas within Peru. This difference is clearly demonstrated by examining disparities in the quality of education between these areas at the department level. For example, in 2004, 90.58% of all Peruvian primary school teachers had received proper teaching accreditation from the Ministry of Education. However, the percentage of teachers with accreditation in the predominantly rural departments, in the Amazonian basin, and in the sparsely populated northern portions of the country, was much lower than the national average. In the three Amazonian Departments only 73.52% of teachers had received accreditation, with Loreto scoring the lowest at 62.28%. In contrast in the urban Departments of Lima and Cusco, the financial and tourism centres of the country, 93.58% and 95.07% of teachers had proper accreditation respectively (*Ministerio de Educación*, 2007b). The disparity between rural and urban accreditation is shown in Figure 4.5.

The socio-economic disparity between rural and urban education quality is similarly apparent from a disaggregated evaluation of other indicators. According to the 2004 school census conducted by the MINEDU, there are 29,893 public primary schools in Peru. Of these, only 8,443 have consistent access to a reliable power supply (an additional 2,558 have intermittent or some access to power). For the study area (the Province of Maynas) 123 of 186 schools do not have reliable power. Of these schools only four are located within the urban boundaries of Iquitos, meaning that rural schools predominantly do not have access to power (*Ministerio de Educación*, 2007b). As discussed previously, the penetration of ICTs and the attenuating benefits such as enhanced data collection, increased capacity, and the ability to evaluate education systems at the local level, are dependent on the infrastructure required to deliver these benefits. Clearly, the rural areas of Peru, and Iquitos and its surrounding area in particular, are in need of aid in this regard.

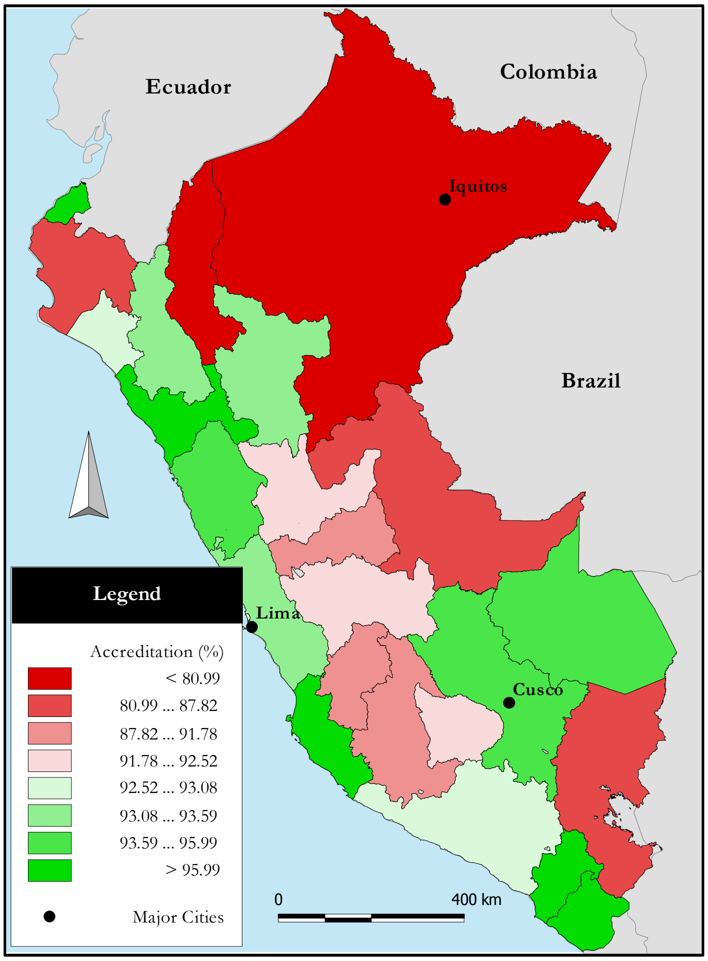


Figure 4.5 – Teachers with proper accreditation by Department (Ministerio de Educación, 2004)

Rural areas also suffer from higher rates of desertion than urban areas. As shown in Figure 4.6, the desertion rate from primary Grade 6 for the rural Amazonian and Andean Departments is generally higher than for the largely urban departments, such as the Department of Lima. Desertion from the final grade of primary school means that students do not continue on to secondary education. As noted previously, completion of both primary and secondary education is critical to the long-term outcomes for students, and to increased rates of return on investments to the education system. High rates of desertion from the education system at the final primary grade may be largely indicative of inefficiencies within the system, caused by high levels of absenteeism, as well as grade repetition. Other contributory factors may include the quality of the schools, infrastructure, or teaching (noted previously by the lower proportion of teachers with accreditation), or socio-economic circumstances and the increased need for children to work outside of school.

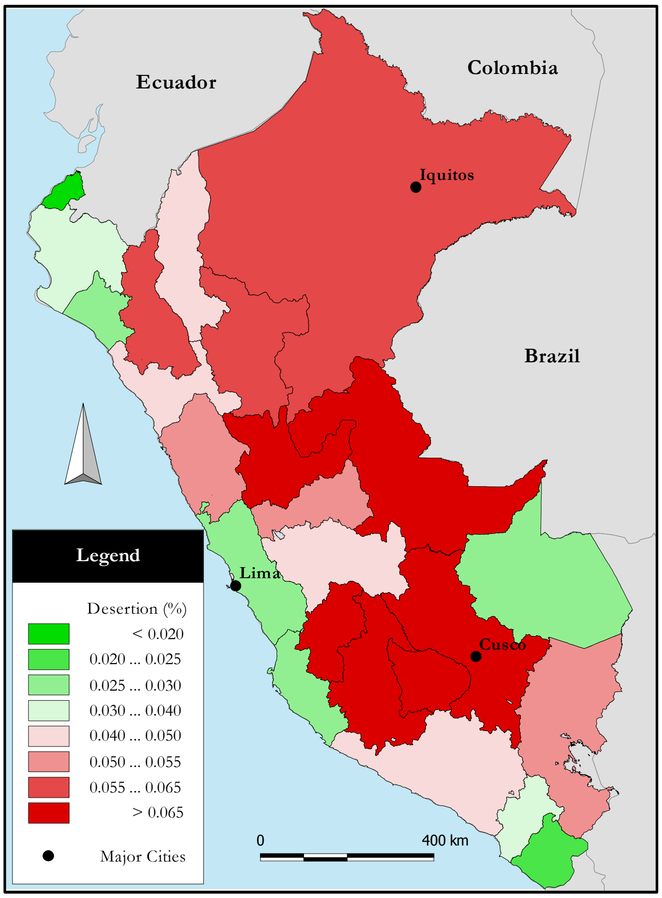


Figure 4.6 – Desertion rate from primary grade 6 by Department (Ministerio de Educación, 2004)

Whether these rural disparities are due to problems within the education system itself, or are the result of the socio-economic and environmental conditions in the communities cannot be directly determined from this highly aggregated evaluation. However, based on the discussion above and in previous sections, it is reasonable to conclude that there are factors both internal and external to the education system in rural areas that lead to the under performance of the education system. Surveys conducted by the MINEDU and the INEI in 2004 found that over 26% of the students that were promoted from primary

Grade 2 in rural areas could not meet basic literacy requirements. In contrast, in urban areas, less than 8% of population that were promoted from primary Grade 2 lacked reading and writing skills. This suggests that the quality of education in rural schools is considerably lower, resulting in fewer graduates from primary and secondary education with basic academic skills, such as literacy and numeracy.

Despite this urban and rural disparity the discussion in this section has shown that the overall quality of education in Peru has continued to improve incrementally over the last decade. However, the majority of the gains made have been concentrated in the more heavily populated urban areas of the country. A disaggregate evaluation of education indicators shows that Peru is still a long way from achieving universally high levels of education quality. The next section continues this discussion, focussing on the current data infrastructure of the MINEDU. A description of the current data holdings, including the shortcomings and omissions of the current databases, is first provided, followed by a description of the capacity of the MINEDU to evaluate its own data.

4.2 Education-based Information Infrastructure in Peru

This section provides a summary of the current education information collection and dissemination infrastructure in Peru, including an assessment of the flows of data and information within the Peruvian education system relative to the ideal data and information flows described previously in Figure 3.1. External reporting of data to the public and other stakeholders is also discussed. Taken together, this addresses not only how education-based data are currently collected but also how they are used at various levels of the Peruvian education hierarchy. The usability (i.e., currency, completeness and accuracy) of the format in which data are stored is critical relative to the ability to include them in an analysis of the education system. Thus, the final section of the chapter discusses the usability of the available data at the national level and at the level of the study area.

4.2.1 Current Education-based Information Infrastructure

The primary source of education-related data in Peru is the MINEDU. Information is collected for each student in the education system through a standard registration form known as the *Ficha Única del Alumno* (unique student registration form). This form is completed upon enrolment in the education system and records information specific to the student such as name, age and gender as well as basic information about the student's home and family characteristics. Each student is assigned a unique identification code that s/he carries throughout his or her school career. In principle, this code can be used to track the student and analyse their performance and achievements from year to year. Completing the registration form requires a short interview involving the prospective student, her/his parents, and either a teacher or school official. Enrolment campaigns conducted at individual schools at the beginning of each academic year are commonly used to ensure that these forms are filled out fully and correctly. In rural regions local and regional education administrators assist with this process.

Ongoing data collection for each student occurs through in-class teacher designed testing, standardised Ministry-mandated testing and, in some cases, daily or weekly student performance, behaviour and progress reports. Student achievement on standardised tests is reported to the local, regional, and national levels of the MINEDU (usually directly to the UGEL which then aggregates and reports the data to their respective DRE). The other measures of performance and achievement are not usually reported beyond the level of the school and/or community. Instead they are synthesised by the teacher and then reported directly to students and parents in the form of a report card at the end of each school term. No national mechanism exists for quality control of these report cards, and thus the standard of grading and the quality of the information contained in them varies from region to region, as well as from school to school. Differences in the method and system of grading are also common. For example the use of numerical and alphabetical grading systems occurs both within and between UGELs and DREs.

Teachers are also provided with a *cuaderno de control* (control notebook) to record informally student performance and behaviour information on a daily or weekly basis. Use of these notebooks is not mandatory, and the information contained in them is not reported back into the education system. The intention of these notebooks is to provide the teacher with a standardised resource to record information about student behaviour and performance for later recall when preparing report cards. In addition, many teachers keep personal notebooks to record student absences and other information relevant to the management of the classroom. The information in these notebooks is again not reported to the MINEDU, and these valuable student-level quantitative and qualitative data, including instances of and the reasons for absenteeism or the state of the student's health in relation to their behaviour or performance is not retained. This information is critical, however, for assessments of pedagogical practice, the impact of policy reform, or more generally the efficiency and effectiveness of the education system at the classroom level.

Classroom and school level information is collected by teachers, administrators and UGEL staff at the behest of the MINEDU for the annual *Padrón Regional de Centros Educativos* (Regional Register of Education Centres), and the *Censo Escolar* (Scholastic Census). These reports contain important administrative information such as the name, *Código Modular* (unique school identifier), and location of the school, as well as the contact information of the current school administrator. These reports also retain data concerning the construction date, size and structural condition of the school. The number and function of rooms within the school are also included, as well as the availability of resources such as administrative personnel, computers, and books. Data relating to socio-economic contextual conditions are recorded in these reports, such as the most common mode of transportation, and the maximum distance that students must travel to attend school. Finally, teacher work evaluation forms and administrative reports are used at the classroom and school to collect data related to administrators and teachers. This report is conducted at the end of the school year, and thus all data provided to the DREs and the MINEDU provide only a snapshot year-end overview of the education system.

The DREs require each school to submit a formal report at the end of every school year. This report, the *Acta de Evaluación Consolidaría de Fin de Año* (Annual Consolidated Evaluation Report) contains much the same information as the report card given to students, albeit in a more standardised format. Information such as student grade by subject, overall final grade and comments concerning the student's performance are included. When students leave a school the report notes the date of departure rather than a final grade. Their new school (if any) is not recorded, and the reason for leaving the school is similarly not included. At the highest administrative levels the MINEDU also generates nationally relevant data such as funding inputs (both internally via taxation and user fees and externally via foreign aid) and resource acquisition to the education system as a whole. Table 4.2 shows the data and information that are commonly collected at each level of aggregation, and the instruments employed for their collection. It is clear from this figure that the majority of data collection should take place at the local level, either within schools for education-based data or communities in the case socio-economic context data, which is in principle ideal relative to the highly variable nature of local needs and conditions.

The education-based data collected by the MINEDU are supplemented by socio-economic data, including the returns from the national census conducted by the INEI. The census is conducted on average every ten years, with smaller regional censes taking place at more regular intervals, and it contains data such as household family size, age of family members, and the languages spoken in the home. Characteristics of the homes such as their floor, wall and roof materials, date of construction, and access to power, water and sanitation are also typically part of the census.

The MINEDU also undertakes a nutrition survey, which samples student height relative to their age. This survey is conducted only at a small subset of schools and is produced at irregular intervals. While these socio-economic context data do not specifically refer to education processes that occur within the school, they are critical for evaluating the nature of the education system in terms of socio-economic contextual influences on education quality.

In a well formed and functional data collection and dissemination strategy, a reciprocal flow of knowledge, in the form of policy and locally sensitive resource allocation would be returned to the local level based on the expressed and revealed needs. It is not clear to what extent this happens in Peru (if at all), especially with respect to rural, remote, and marginalised schools. For example, it is not uncommon for remote schools in rural areas to have a single classroom under the responsibility of a single teacher who is required to teach all six primary grades simultaneously. The extent to which these teachers are able to collect and report data properly to local and regional authorities, and reciprocally, the extent to which classroom level changes can be enacted based on policy decisions of the MINEDU is at best highly questionable. Additionally, a large component of the exchange of information between participants at the local level is work-related in nature (i.e., associated with essential communication of knowledge between school administrators, teachers, students, and parents in order to facilitate a positive education experience at the classroom level). This sort of qualitative information and knowledge sharing, although critical to the functioning of the education system, is difficult to capture and report to higher levels of the education system.

Level	Educational Level	Data Collected	Instrument
National	MINEDU	• Generalised statistics National indicators (e.g., funding) • Progress indicators	• National census • EFA indicators
District	DRE UGEL	• School statistics / administration • District summaries	• Curriculum diagnostics • Project diagnostics
Local	School	• Administrative technical Curriculum and project • Strategic intervention planning	• Grade records • Auxiliary records Lesson plans
	Teacher	• Student academic • Contextual (classroom) • Pedagogical	• Lesson plans • Teacher notes
	Student	• Student characteristics • Contextual (socio-economic)	• Unique student records • Standardised testing

Table 4.2 – MINEDU data collection
(Ministerio de Educación, 2004)

The data that are collected are widely disseminated both internally to education practitioners, and externally to the government, other ministries and the general public, via an annual report of basic education statistics for all Peruvian schools as required by the norms of an open and transparent democracy. This dissemination includes public media-based advertising campaigns as well as publication of national education statistics from the *Censo Escolar* via the *Escale* Web portal (*Ministerio de Educación*, 2007b). Unfortunately, local participants in the education system, as well as stakeholders in the public in general (e.g., students and parents), are often either unaware of the availability of these data, lack the necessary capacity, confidence or time required to use them, or are unsure of the potential usefulness of these data for local problem solving and knowledge development. Given the lack of capacity building directed at local level practitioners it is understandable that local participants in Peruvian schools have anecdotally indicated the lack of priority they place on data collection for the MINEDU.

4.2.2 Data Availability and Usability in Peru

The concepts of availability and usability of data delineate, in combination, the analysis that can be appropriately conducted. Availability is often a Boolean concept (e.g., the required data are either available or they are not). This approach to availability is enhanced, in the case of education-based data, by breaking down availability to include various administrative and geographic levels of aggregation. For example, data measuring funding inputs to education at the national level are not appropriate to assess the funding available to a single school for the purchase of new textbooks. In contrast, usability covers issues such as currency (timeliness), accuracy and completeness of the data. Clearly, more current data are more appropriate for analysis as they describe better the actual conditions and experiences of an education system or of a population. Accuracy of the data is critical, as evaluations produced from inaccurate data may lead to disastrous policy changes within an education system. Finally, completeness refers to data that are well-formed, meaning that data were reported for all instances and in all cases. Taken together available and useful data are critical to policy reform and decision-making in education systems.

Much of the potentially useful data collected by the MINEDU and the INEI are not readily available at local levels due to the national policy of withholding data in disaggregate form due to privacy concerns. While this policy is normative with respect to government data distribution and dissemination in the majority of developing and developed nations alike, access to disaggregate data without violating the privacy and security of the individual is possible, and even more importantly, is required by researchers, academics, and policymakers in order to produce local level analyses of education quality. In Peru, disaggregate data at the school or classroom level are only available through formal requests to the custodian Ministries or institutions of these data. In cases where disaggregate data are provided, usually for a cost-recovery based fee to academics and researchers, the identity of individual students (including their unique registration number is concealed).

Table 4.3 lists the availability (including level of aggregation), usability (currency) and source of the datasets described in the previous section, as well as other relevant socio-economic contextual datasets available from outside the MINEDU. From the table, it is clear that there are broad concerns with the usability of the data, especially with respect to currency. Ideally these data would all be related and disseminated via a nationally controlled EMIS. In principle, this would allow them to be used by the MINEDU, the DREs and the UGELs to describe and support their internal policy and research studies. However, the extent to which this occurs is not clear. For example, the extent is unclear as to which information and knowledge derived from data holdings (i.e., from EMIS) are able to influence political decision-making processes. This is reflected in the fact that MINEDU policies are generally broad in scope and reflect a national-level perspective that is clearly insensitive to the local needs of the many different communities across the country.

Dataset	Content	Source	Date(s)	Aggregation	Availability
Basic school statistics (*Padrón*)	Basic descriptive information and summary education data for schools	MINEDU	1998-2005	School level	Publicly accessible on-line from the MINEDU website
Annual school census (*Censo Escolar*)	Detailed data about students, staff and infrastructure for schools	MINEDU	1998-2005	School level	Publicly accessible on-line from the MINEDU website
Student registration forms	Descriptive information about student and family characteristics	MINEDU	All years	Student level	Effectively not available, except through direct context of local offices
Student height and nutrition surveys	Sampled data of nutritional status and height of students in grades 4 and 6	MINEDU	1993, 1999, 2005	School level (limited sample)	Publicly accessible on-line from the MINEDU website
National population and housing census	Contextual data about the socio-economic and demographic characteristics of the Peruvian population	INEI	1993, 2005	Block (urban) or Population Centre (rural) level	May be purchased from the INEI

Table 4.3 – Availability of education-based and socio-economic context data in Peru (Adapted from Leahy, 2005)

Data currency is reduced when teachers and school administrators focus their time on immediate tasks, and do not report required data at the appropriate time to higher level authorities. This occurs largely due to the MINEDU's inability or unwillingness to inform local-level practitioners of the value and importance of collecting these data. This leads to situations where data are only partially reported or are simply not reported at all. In the case of private schools, data are often not reported to higher level authorities as there is no mandated requirement for them to do so. Furthermore, data have been in some cases intentionally incorrectly recorded (e.g., small schools inflating the number of attending students to avoid closure or reduction in funding). In addition, deliberate falsifications in data reporting such as artificially inflating test scores to promote more students to subsequent grades introduces unknown and hard to trace errors into the national databases. Thus, data usability is severely affected where incentives to report data accurately do not exist or especially where there are disincentives for doing so such as reduced pay or loss of holiday time for teachers and principals when students do not perform to a nationally-mandated standard.

Additional limitations to the type of evaluation that can be conducted are based on the nature of the data collected. Virtually all the data collected for assessing education quality are quantitative in nature, for example numbers of students (categorised by grade, sex, promotion/desertion status, etc.), numbers of teachers (categorised by grade, sex, employment status, certification, etc.), and school infrastructure (including data pertaining to the number of classrooms, desks, computers, labs, libraries, etc.). While these data are relatively well documented, and largely mirror the 18 core EFA indicators as well as other standardised international education data reporting frameworks, their content, format, and data definitions have changed with each new report issued. This makes using the data for monitoring change over time complicated, as variables are stored in different tables, recorded with different names, defined and/or calculated differently, or not recorded at all from one report to the next.

In addition, indicators which are calculated from the MINEDU and INEI data holdings can become decreasingly accurate over time, given that some of the raw data inputs are updated more often than others. For example, indicators that are calculated using data from the 1993 census (disaggregate data from the 2005 census were not available at the time of writing and are unlikely to be released below the district level of aggregation) become less accurate when combined with more recent data. An indicator such as the gross enrolment rate (GER), which compares the total number of students enroled in a particular education level expressed as a percentage of the total population of the eligible corresponding cohort, is a good example of this, as the population data are derived from the increasingly outdated census data, whereas the enrolment data are provided annually from MINEDU data collected at the school level.

As well, indicator data are often unavailable for rural schools and communities largely because they are rarely reported on time. This lack of timeliness in reporting is largely a result of limitations in capacity and resources associated with rural socio-economic and environmental contexts in Peru. For example, in the Province of Maynas, the *Acta de Evaluación Consolidaría de Fin de Ano* is submitted to the local UGEL in hand-written form well after the end of the school year. Staff at the UGEL must subsequently transfer these documents into standardised MINEDU templates. Teachers are generally not available to assist this process and thus issues such as completeness, accuracy or legibility of the submitted report are left unresolved. Clearly, this entire process takes significantly longer than the normal urban process whereby computer-based forms are emailed directly to the proper authority. Further exacerbating the problem, in the case of Maynas, is the fact that these forms are warehoused and no electronic copy is retained. In addition there is little evidence that these reports are analysed at the local or regional level, checked for completeness or accuracy or mined for valuable longitudinal performance data prior to being warehoused.

The INEI socio-economic context data holdings are also problematic with respect to usability. The most recent census data that are available from the INEI for local level analyses date from 1993. Disaggregated values from the 2005 census are not likely to be available prior to 2008. While most likely the result of limited resources this lag limits the timeliness and accuracy of interventions into social policy on the part of social policy planners within the Peruvian government. This multi-year lag also severely limits the ability of other Ministries within Peru such as the MINEDU to link these data to their own data holdings and produce timely and accurate policy interventions relative to their needs and goals. This leads to a situation where multiple datasets of varying scope, purpose and structure are collected across the country with no plan for integration or centralisation of these data.

Thus, an assessment of the MINEDU and INEI data holdings reveals a large volume of data of inconsistent quality with respect to availability and usability. The discussion to this point, however, has focussed only on the quantitative data collected by these Ministries. However, the link between socio-economic context and the other four school-based components of the education model is based on both the physical locations and the spatial relationships between homes and schools, as previously discussed. Thus, in addition to the data sources identified in Table 4.3, spatial data are required in order to produce the spatial analysis presented in Chapter 6. Table 4.4 lists the layers of spatial data that are available from the MINEDU and the INEI.

These layers coincide with the political and administrative boundaries of Peru, including the areal boundaries of the various levels of the MINEDU hierarchy, and are provided in Shapefile format. This is an open specification for data interoperability created by Environmental Systems Research Institute (ESRI) for their software and GIS software developed by other vendors and institutions. Although the name implies a single disk-based file, a Shapefile is actually comprised of a minimum of three files, one containing the shape information (.shp), one containing the attributes associated with each shape (.dbf), and a shape index file (.shx).

Common problems with the spatial data listed in Table 4.4 stem from the absence of documentation describing their content, how and when they were created, their accuracy, their lineage and whom they were created by among many other attributes. This documentation is known as geospatial metadata and its form and content are regulated by large-scale geospatial committees such as the Federal Geographic

Data Committee, based in the United States (Federal Geographic Data Committee, 2006). A lack of metadata is particularly problematic since multiple datasets from multiple sources may use different geographic projections, different levels of generalisation relative to the source data, different unique identifiers, and may relate to different points in time.

Dataset(s)	Spatial Type	Source	Date	Format	Availability
Departments, Provinces, Districts	Polygon	INEI	2000	Shapefile	Publicly accessible on-line from GIS data warehouses (e.g. http://www.geocommunity.com)
DRE	Polygon	MINEDU	2000	Shapefile	Generated manually by the NGO Alternativa (http://www.alter.org.pe) from district datasets and tabular data
UGEL	Polygon	MINEDU	2000	Shapefile	Generated manually by the NGO Alternativa district datasets and tabular data
City blocks	Polygon	INEI	1993-2001	Shapefile	Available for purchase from INEI
Population Centres	Point	INEI	1993	Shapefile	Available for purchase from INEI
Population Centres	Point	MINEDU	2000	Shapefile	Available upon personal request from MINEDU staff
Schools	Point	MINEDU	2000	Shapefile	Available upon personal request from MINEDU staff
Province of Maynas School location Map	Scanned Map Image	MINEDU	Unknown	TIFF	Publicly accessible on-line from the MINEDU *Escale* website

Table 4.4 – Availability of spatial data in Peru
(Adapted from Leahy, 2005)

In addition, spatial data for Peru are not generally freely available online, apart from basic highly generalised features that are distributed through various external online portals (e.g., major cities, waterways, transportation, political and administrative boundaries, etc.). More relevant and important spatial features such as school locations, city block boundaries and rural population centres are not available from these external portals. Data related to these features must be obtained upon request from the MINEDU (usually by visiting central or regional offices in person) and through purchase from the INEI.

The discussion of data availability and usability thus far has focussed on point, line, and polygon (i.e., vector-based) spatial data. Spatial data, however, also comprise raster (gridded) data and imagery. The latter category of spatial data includes satellite imagery, aerial photography, and digital scans or reproductions of paper-based maps. Through the process of georeferencing, these digital maps can be adjusted to real world coordinates so that they are spatially coincident with point, line and polygon spatial data layers. This allows features from the digital imagery to be added to the spatial layers by placing points or line or polygon outlines over these features using a GIS. This process, known as table-based or 'heads-up' (on screen) digitizing, adds features to the spatial data layer. Once feature geometry is created, the attributes of the new feature can be applied. Figure 4.7 shows a geo-registered map image of school locations in the Province of Maynas.

Figure 4.7 – Geo-registered map image of Iquitos
(Ministerio de Educación, 2004)

Finally, despite clear efforts by the MINEDU and the INEI over recent years to ensure transparency with respect to the collection and use of data, significant gaps still remain between the data that are collected, the data that are available at appropriate levels of aggregation and the data that are actually used in education planning and decision-making. In particular, collection of a process-based indicator such as absenteeism is not mandated by the MINEDU, despite its clear value as a measure of education quality. Absenteeism, as noted previously, may reveal the influence on education quality of factors external to the classroom such as student morbidity, the socio-economic condition of the student's neighbourhood, or the prevalence of child labour. Thus, this indicator is a useful proxy for exogenous socio-economic and environmental contextual factors that can interrupt the continuous process of education. In addition, process-based indicators such as absenteeism are commonly used by teachers at the local level to monitor standards and norms of preparedness, engagement in learning, and conduct within the classroom. By not reporting absenteeism, and other relevant process-based indicators, critical local level information about the efficiency of education systems, and the relationship between home and school locations remain missing from discussions related to the efficiency of education systems.

4.2.3 Data Availability and Usability in the Study Area

The data usability and availability issues noted in the previous section are exacerbated at the level of the study area, most likely due to the largely rural and remote nature of the province of Maynas. Moreover, it is a reflection of the generally poor state of understanding of the value of these data and the lack of capacity-building by the MINEDU to support the proper collection and reporting of these data. For example, of the 186 public primary schools in the Province of Maynas only 128 have reported data for the majority of the indicators in the 2004 *Censo Escolar*. Of these 128 schools only 27 (all within the urban portion of the study area) have reported completely the data required of them by the MINEDU.

The completeness of the education-based data is even more problematic for the rural portion of the study area. While data reporting for schools within the urban limits of the city of Iquitos tends to be more complete (with 81.4% of schools reporting data), almost no data have been reported from many of the rural schools in the Province (with only 64.6% of schools reported some data). The result is that 11 and 45 schools from the urban and rural portions of the study area respectively have insufficient education-based data to be included in any evaluation of education quality.

The INEI data holdings suffer from the same issues of completeness. Socio-economic contextual data available from the INEI are aggregated either at the city block level (for urban areas), or population centre level (for rural areas). City blocks, or *manzanas*, are defined by irregular polygons with boundaries coincident with street edges, and/or the edges of water or other natural barriers. Rural population centres, or *centros poblados* (CCPP), are defined by points that correspond roughly to the geographic centre of the settlements they represent. *Centros poblados* are extensively used throughout the Amazonian region to locate smaller settlements that have no road names (or in many cases no roads), addressing system, or public infrastructure (such as water). In Iquitos data were reported for 1103 of 1492 city blocks in the 1993 census. However, only 143 of the 486 population centres reported socio-economic data. Again, even where data were reported, not all data required were included in the data submitted.

One other source of data not yet mentioned comes from the Ministry of Health (DISA in its Spanish acronym). Clearly, being able to correlate health visits and or patient records to instances of student morbidity would be highly beneficial to the analysis presented in this thesis. However, the data provided by the DISA were rejected due to errors of completeness and accuracy. Overall there are a total 41 health centres in the study area. However, patient visits were recorded for only 32 of these health centres. A further problem with the DISA spatial data is that only 13 of these 32 health centres can be linked to the spatial data via their unique identifiers. The remaining health patient visits are linked to health centres that are not identified in the spatial data provided by DISA. It is not clear whether this is due to an error in recording the unique identifiers (in either of the datasets), or is the result of changes to the identification codes used by the DISA which are not fully reflected in the spatial and indicator datasets.

In general, the process of developing indicators from the source data is encumbered by a lack of completeness, accuracy, documentation, and consistency of the data, as well as the somewhat unconventional methods of storing and/or documenting the data (Leahy, 2005). These challenges are further exacerbated by a lack of coordination between organisations collecting data, namely the MINEDU and the INEI. Despite these limitations a series of indicators can be developed from the available source data for inclusion in the EMIS that is described in the following chapter. However, conversion of these data from their multiple sources into EMIS requires intensive pre-processing including intensive error-checking.

A total of 724 individual indicators have been developed from the MINEDU data holdings (Leahy, 2005). Many of these indicators represent aspects of a single indicator definition that can be categorised according to grade and gender, as they refer specifically to student-level information. In addition, many of the indicators can be categorised by other internal characteristics. For example, the total number of teachers with proper accreditation is categorised according to the number of teachers qualified to teach each specific subject. With respect to the five-component education system model, the data provided by the MINEDU (from both the *Padrón* and the *Censo Escolar*) contain 302 input indicators, 229 process indicators, 20 output indicators, and two outcome indicators (measuring youth and adult literacy). A further 171 individual indicators can be developed from the MINEDU nutrition survey and from the 1993 INEI census.

As can be clearly seen from the distribution of indicators over the components of the model, the output and outcome components are severely under-represented. Furthermore, the input component is heavily over-represented suggesting that data collection at the student level decreases as the student progresses through the education system. Clearly, it is very difficult to evaluate an education system where there is a lack of continuous monitoring and evaluation of the education quality received and the benefits accrued from that education. Context, on the other hand, is well represented yet the majority of these indicators come from the census which is not current, and thus the value of these indicators is greatly diminished.

A closer look at the education indicators reveals that the majority of them cannot be used for an assessment of the study area due to a lack of completeness. In particular, 108 of the indicators derived from the *Censo Escolar* are unusable due to an extremely low rate of reporting from the schools in the study area. Extremely low reporting is defined here as indicators with greater than 75% null values, or indicators with greater than 50% zero values (where zero is not within the range of the indicator). Furthermore, another 130 indicators were removed from the available education-based indicators due to irresolvable errors in the reported values. The end result is that 14 input, 25 process, zero output, and two outcome indicators available at the local level for an evaluation of education quality and an assessment of the effect of absenteeism on the quality of education.

For the context component data the entire set of data from the MINEDU nutrition survey (18 indicators) is complete and available for use in the analysis. Of the INEI census indicators only 65 are complete and available for the analysis in this thesis. Combined with the indicators from the education-based data, there are a total of 109 indicators with complete data available for the analysis. Thus, even with the many issues with respect to quality and completeness discussed above there remain enough indicators with which to conduct the analysis.

The spatial data at the level of the study are also incomplete. Many schools, especially in rural areas are often located in multi-purpose buildings rather than stand-alone schools and this often causes confusion in determining school locations between data sets. This is especially apparent in Amazonia. A large proportion of the schools listed in the MINEDU data holdings have no corresponding geographic locations in the MINEDU spatial data. For example, in the study area, only 62 public primary schools are listed in the spatial layer of school locations (57 of which are located within the urban boundary of Iquitos) while the *Censo Escolar* and *Padrón* data contain information for 735 distinct public primary schools within the province. This problem was partially overcome by digitizing 150 school locations from a scanned map of the province. This map was obtained from the *Escale* web portal, without metadata, and thus is of an unknown date and origin.

Finally, in rural areas of Peru two completely different sets of points have been collected by both the INEI and the MINEDU for population centres. While these two sets of points are spatially coincident across the majority of points they sometimes have different locations and/or different names (usually a matter of spelling errors, abbreviations, or short versus long representations of a place name) despite representing identical features. Additionally, the spatial locations in these two different datasets were collected approximately ten years apart, yet they are still considered current by the respective ministries. Given the need to digitize the majority of the schools for the analysis in this thesis, and the relative stability of urban school locations, the MINEDU supplied points were used to locate the schools in the study area.

4.3 Summary

This chapter has provided an overview of the history and context of Peru along with a discussion of education planning, education quality with respect to socio-economic context, and the availability and usability of data necessary for the analysis of education quality in Peru in general, and the study area in particular. This chapter has also noted that education planning, and the role of the education system, in Peru has changed significantly since the establishment of the MINEDU. The government has embraced the concept of decentralisation in the education arena and as a result has adopted a program of local-level nation-wide education data collection. This decentralisation is due in part to the influence of international efforts such as the EFA process. Overall, these efforts make it possible to work to improve education quality at localised levels by using and enhancing the available data holdings of the MINEDU as well as the INEI. The second part of this chapter focussed on the current education-based and socio-economic context data available in Peru for the analysis of education quality. The data that are available and the usability of these data were described with specific reference to the study area. The following chapter discusses in more detail the development of s-EMIS, a data model for education analysis and the extension of the MINEDU and the INEI data through the collection and calculation of an absenteeism indicator. Use of this indicator to strengthen the evaluation of education quality is discussed along with methods for aspatial and spatial analysis of the quality of education.

Chapter 5

Modeling and Methods for the Analysis of Student Absenteeism

The previous chapters have identified the importance of data, information and tools such as education management information systems (EMIS) for the analysis of education quality in support of education planning and decision-making. While data for this purpose do exist in Peru, a general lack of their availability at disaggregate levels and concerns about their usability (including completeness, accuracy, and currency) prevent them from being easily incorporated into GIS and used to assess education quality at the local level. In addition, the MINEDU lacks the capacity, especially at local levels, to undertake spatially-based evaluations of education quality with GIS tools and methods. This chapter addresses these concerns by developing methodologies for the collection of data at the local level and by describing a data model for the analysis of new and existing data describing education processes. The first section describes an hierarchically organised spatial data model (spatially-enabled EMIS, or s-EMIS) that can be created from the available and usable data described in Chapter 4. The second section discusses the definition and the sampling design for new indicators of absenteeism. The resulting sample is evaluated with respect to its internal characteristics (age, grade and gender). The process for adding these new indicators to the data model follows. The final section discusses spatial point pattern analytical methods that may be used in conjunction with an s-EMIS to assess education quality and the effect of absenteeism on the quality of education at the school level.

5.1 Development of an s-EMIS for Education Quality Analysis

There are many benefits to developing a data model and adhering to standardised relational database conventions, including the ability to develop EMIS for the analysis and dissemination of education-based data. Further, the analytical power of traditional EMIS, which was discussed previously in largely non-spatial terms, can be extended to include spatial analytical methods. This takes advantage of the fact that the data contained within an EMIS database describe real world processes that either occur at discrete geographic locations or within distinct geographic boundaries (i.e., at schools or within the administrative boundaries of various levels of the education system). This extended spatial analytical capability is generated by combining the relational database structure of an EMIS with GIS software. The development of an s-EMIS requires both the calculation of indicators from source data (as described in the previous chapter) and the development of a hierarchical structure for the aggregation and representation of these indicators at multiple levels which correspond to administrative boundaries of influence within the education system.

5.1.1 Structure of an Hierarchical s-EMIS

As discussed previously the methods of data collection and storage employed by the MINEDU and the INEI do not follow any specific data model or any standards common to conventional data models. However, there are many benefits to having a standardised and effectively implemented data model especially with respect to hierarchical systems as complex as systems of education. For example, the administrative structure and the inherently spatial organisation of the education system in Peru easily lends itself to a representation using a hierarchical data model where multiple normalised data tables can be linked through the use of primary keys that uniquely identify individual objects (e.g., DREs, UGELs, schools, classrooms, teachers, and students). Thus, a data model is a structured way of viewing a set of data including the design of the tables and their corresponding relationships (schema) in a relational database to support the evaluation and monitoring of an hierarchical organisation (such as an education system).

Thus, the design of an effective data model for use in the Peruvian education system should follow the overall hierarchical structure of the education system, as indicated in Figure 4.3. The database of an s-EMIS has the same overall structure as a typical relational database, with the exception that it contains a geometric field (as opposed to numeric, time and date, or text values) which describes the actual physical shape (point, line or polygon) and location (coordinates) of a discrete real world feature. The decision to represent a real world feature, such as a school, as either a point (describing location only) or as an irregular polygon (describing the location and footprint of the building) in the database is based on the scale at which the data are captured as well as the type of analyses that are to be conducted. Representation of features as points allows for specific methods of spatial analysis to be conducted such as spatial autocorrelation, cluster analysis and geographically weighted regression. These methods are described fully in the second half of this chapter. An s-EMIS database (also referred to as a geodatabase) extends the capability of a conventional relational EMIS database design by allowing a variety of spatial calculations to be performed with the geographic data (e.g., buffer, contains, and intersects) in much the same way that arithmetic calculations can be performed within a database (e.g., addition, summation, normalisation).

Data models are useful to support accountability and evaluation of education systems and to monitor the improvement in student achievement. The architecture and content of a data model defines the kinds of research and evaluation that can be conducted with respect to the education system. The content of a data model is dependent on the data collected and reported from all hierarchical levels of the education system, and thereby defines the use of the data model to support aggregate and disaggregate analysis of education data, and education policy planning. The content and architecture of a data model, in turn, limit the models analytical capabilities and, therefore, their ability to support systemic evaluation and help increase education quality at local levels. The content and structure of a data model also affect the ability of the education system to share and connect to relevant data from other ministries and government agencies.

In a hierarchically organised s-EMIS, the features at any level of aggregation are geographically contained by a parent feature at the next highest level of aggregation. For example, in Peru the boundaries of a set of co-located provinces are contained within the boundary of one department. Indicator values are directly associated with each of the various levels of aggregation, such that there is one value for each indicator for each feature at each level of aggregation. Indicator values for each level of aggregation are calculated from the source microdata reported from the lowest level of aggregation (i.e., from schools and households). Where there are missing or incomplete school-level data with which to calculate an aggregated indicator value for a particular feature, the indicator values may be derived by averaging the values for the child features from the next lowest level of aggregation associated with the feature in question.

For example, the gross enrolment ratio (GER) for the Department of Loreto can be calculated by averaging the GER values reported from each province within the department. This method may be appropriate in some circumstances, however, averages calculated in this way disregard the distribution of the underlying population among the child features of the parent feature in question (i.e., the distribution of population among the provinces within the department). Calculated in this way, the reported GER value from a province containing 300 schools is given the same weight as the GER value from a province containing 3000 schools. Thus, calculating aggregated indicators in this way gives undue influence to less populated areas of the country, and for this reason, this method was not used to calculate the aggregated indicators in the s-EMIS developed for this thesis.

In Peru, the boundaries of the higher political administrative divisions (i.e., province and department) are largely, but not universally, mirrored by the boundaries of the administrative divisions of the education system (i.e., UGEL and DRE). An effective s-EMIS data model built from the available and usable data, shown in Figure 5.1, should mirror these advantageous spatial coincidences as they simplify data aggregation from multiple sources, and provide intuitive linkages between the education-based and the socio-economic contextual data. In addition, the education system in Peru easily lends itself to the data model discussed here, due to the inherent vertical hierarchy of the system, and the organisation of the individual features within the system (e.g., administrative divisions, schools and classrooms). These features are represented in the data model by geographic constructs, and referenced by unique MINEDU-assigned identifiers. Higher levels of the education system are represented as irregular polygons that define the boundary of influence of these authorities. Individual schools on the other hand, are represented as point locations, and are located by northing (x) and easting (y) geographic coordinates that identify the location of these features in real world geographic terms.

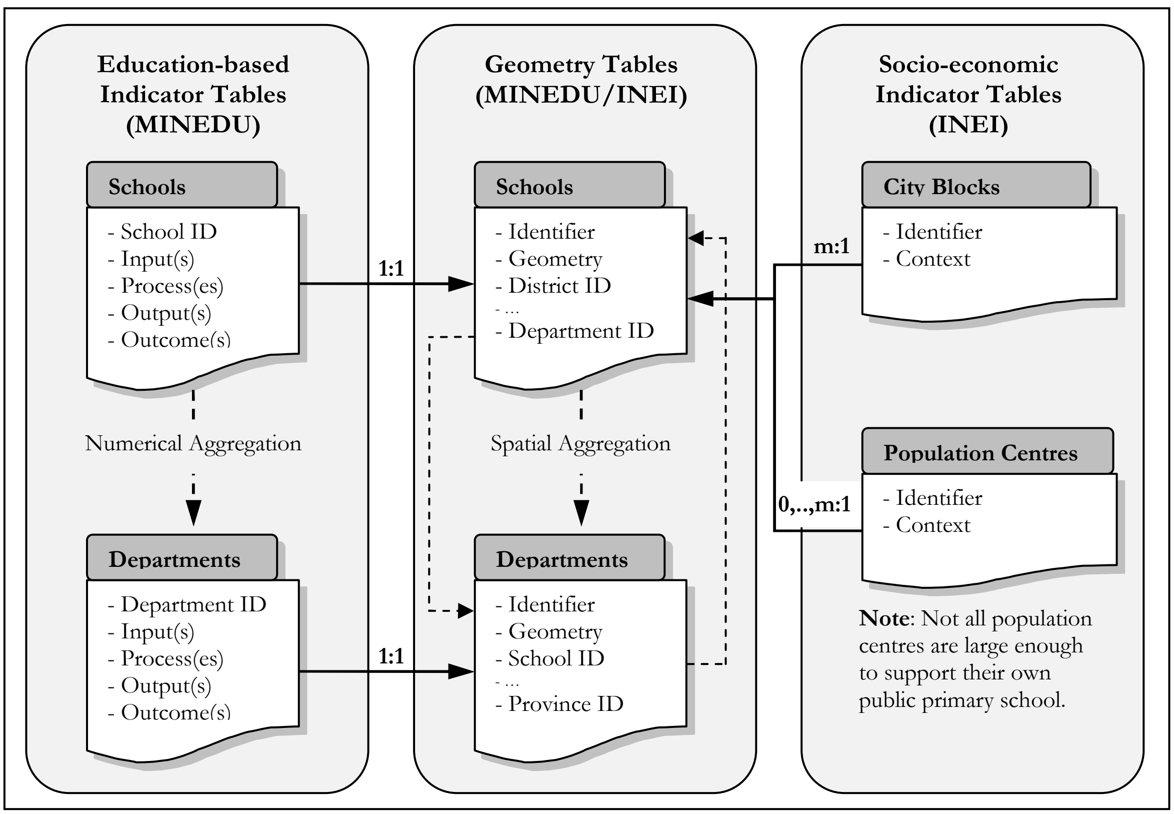


Figure 5.1 – Structure of an hierarchical s-EMIS

An s-EMIS is also flexible enough to allow for indicators collected from sources outside the MINEDU to be included. For example, census data from the INEI, which measure the context component of education systems, can be easily incorporated into a hierarchical s-EMIS by adding a new table object to store the data. These census data from the INEI are also spatially referenced back to their reporting units (households, city blocks, census tracts, and population centres), and thus can be represented by either points or irregular polygons in the s-EMIS. Including socio-economic data ensures that the s-EMIS is able to store indicators for all five components of the education system.

Ideally, an s-EMIS built on this model would contain all the data in a single centrally accessible Ministry-maintained repository. Access to this repository would be ideally universal via the Internet with access to disaggregate source microdata such as individual student records limited to MINEDU personnel, as per privacy policy, in order to support policy reform and system evaluation. However, this is not strictly required as the model allows for distributed storage of data from multiple sources provided the individual data tables conform to the hierarchical structure of the model, and maintain the same levels of data aggregation, as well as conform to the same unique identifiers assigned to the features. In addition, the ability to use an Internet-based s-EMIS implicitly suggests the availability of computers and a stable Internet connection, as well as the capacity to understand the value and need for such a system, from how to collect and enter data, to how to extract and analyse these data.

This poses a challenge since most data currently recorded at the school level in Peru are normally recorded only on paper, especially in rural areas as discussed earlier. Additionally, not all data collected by the MINEDU and the INEI have incorporated unique identifiers for feature instances, nor do they use consistent unique identifiers across datasets. A common unique identifier is required not only to differentiate between features in the database, but also to relate the data back to their geographic point of collection (i.e., the school at which they were collected). For example, the national student evaluations use an arbitrarily assigned identifier code to identify schools instead of using the MINEDU assigned *Código Modular* used in the *Padrón* and other MINEDU-produced reports. Since these data cannot be related easily back to the school or UGEL from which they were collected they can only be used in national level analyses.

By implementing the s-EMIS described here education planners and decision-makers can access, process and visualise education data in a much more flexible and meaningful way than is possible with the EFA core indicators and national level abstractions of education. Moreover, there are numerous advantages to using s-EMIS that include improvements to data collection, as well as verification of the completeness and accuracy of those data. Other advantages include projects that extend the capacity and knowledge of local-level education practitioners, help develop critical computing skills, and reinforce local-level participation in education policy and decision-making. Lastly, this data model is highly extensible, meaning that new indicators and new levels of aggregation can be added, and new data can be recorded for each year, keeping the database current and complete.

5.2 Definition of an Absenteeism Indicator

For the analysis in this thesis student absenteeism is defined as an instance of missing a day of school-based instruction. While this implies a full day of absence it is equally applicable to situations where schools are in session for only a half day (in these cases the half day is considered as a full day). This corresponds to how teachers in the study area currently informally collect this information in personal notebooks, or on a hand-made calendar mounted on the wall of the classroom. This may seem to over-generalise the total degree of absenteeism. For example missing one class of instruction during the day clearly does not have the same effect on the overall education experience for the student as missing an entire day of instruction. However, the reality of most equatorial developing countries is that students are far more likely to miss an entire school day rather than a just a portion of the day.

This is especially true in the rural Amazonian area of Peru which often experiences bouts of extreme weather, recurrent outbreaks of infectious diseases, and issues of extreme poverty. In addition, students are often required to travel long distances (usually on foot) to local schools. The overall effect of these exogenous factors on attendance is to keep the student away from school for an entire day, rather than a portion of the day, as might be more common in developed countries where routine activities such as doctor's visits and participation in organised external education experiences are more likely to occur. Finally, schools in rural areas often house both primary and secondary classes, the former in the morning, and the latter in the afternoon, meaning that a student who is inclined to miss a portion of the day has a disincentive to invest the time and energy to travel to and partake in a protracted school experience.

Absenteeism is a process-based indicator that acts as a proxy for these and other external factors related to the student's socio-economic context, which manifest as absences from school. However, information concerning student absenteeism is collected only informally by teachers at the classroom level for personal use in assessing performance, attitudes and achievement and there is no mechanism for reporting these data to higher levels of authority. Thus, the opportunity for the MINEDU to evaluate the effect of absenteeism on the quality of education at the local level, as well as at higher levels, is lost.

In this thesis, instances of absenteeism are recorded in terms of the time period of the instance, as well as the duration and the reason. The time period provides a comparative evaluation of seasonal effects on differing reasons for absenteeism. Moreover, recording the reason for absenteeism is crucial for policy implementation and decision-making at both the local and higher levels. For example, absenteeism due to illness is an influence of an entirely different set of circumstances than absences incurred by a student whose parents cannot afford to pay for transportation to a school in a neighbouring community. In both of these cases, the student may register a similar number of absences during a school year, and may be considered, to some extent, to have had their education experience influenced in the same way. However, from a policy perspective, these instances of absenteeism need to be addressed separately.

As noted, informed policy requires knowledge derived from information based on real world data. In the absence of proper data and information, education planners are incapable of addressing concerns within the education system. The following sections address this issue with respect to absenteeism by describing a sampling and collection methodology to support the development of an absenteeism indicator. A statistical assessment of the resulting random sample of urban and rural schools generated by these methodologies follows to support the representative validity of the sample data collected.

5.2.1 Absenteeism Data Collection and Pre-Processing

The value that absenteeism data may add to an s-EMIS cannot be exploited if their intrinsic value is not understood by local level education practitioners. In order to make this value apparent, the informal absenteeism data collected by teachers at the classroom level in Peru need to be systematically assembled, and subsequently linked to the s-EMIS described in this thesis. Results of analyses performed on these data need to be reported back to teachers and local level education stakeholders as practical knowledge that they can employ to improve the quality of education at their schools. To investigate absenteeism in the Province of Maynas a random sample of schools for which data are available and usable must be created. Thus, a random sample of 60 schools was drawn from the 128 public primary schools that reported data to the MINEDU for the 2004 *Censo Escolar*. Of these schools 30 are located in the urban part of the study area, with the remaining 30 schools located in the peri-urban and rural areas. The decision to split the sample along these lines arose due to discussions with local level education authorities and teachers concerning their perceptions of significant attendance issues at rural schools as well as a minimum sample size of 30 to facilitate robust probability-based statistical analysis.

The 60 schools were chosen by listing the urban schools (in no particular order) from one to 48. Thirty random numbers in this range where then generated. The corresponding school at each position on the list was selected as a school to be sampled. The process was repeated for the 82 rural schools reporting data to the MINEDU in 2004. The resulting list contained 60 randomly selected schools at which teachers interviews were to take place. However, due to constraints of time and financial resources it was only possible to visit 41 of these selected schools. Seventeen working days in the field were lost to strikes by teachers, private transportation providers, and other politically motivated groups during the 45 working days scheduled for data collection. On these 17 days it was either impossible to travel to the schools (especially widely-dispersed rural schools), or the schools were closed and thus interviews could not be conducted. In addition, it was not possible to interview every teacher at the larger of the urban schools due to their size and the number of teachers (eight of the urban schools have 40 or more teachers). In cases where not every teacher could be sampled a representative sample of teachers was chosen from each primary grade based on availability and interest in the study.

Teacher interviews were conducted on-site during the school day. It is important to note that teachers in the province of Maynas have significant complaints concerning their treatment and pay (including issues of not receiving pay, sometimes for several months). Due to these concerns teachers are reluctant to be burdened with additional work or to remain at the schools longer than is necessary. These issues are compounded at rural schools where teachers often commute via shared taxis from their homes in urban areas. Given these constraints, interviews were usually conducted at break times, or in the classroom while students were engaged in some directed activity, freeing the teacher up for the 15-30 minutes required to conduct the interview. Permission to access the schools and conduct the interviews with the teachers was obtained in the form of an official letter signed by the president of the local DRE.

The interviews were structured around a data entry sheet, which is shown in Appendix A. This sheet records the grade, age, and name (to determine gender) for each student. This sheet was used to systematise the absolute counts of absenteeism informally recorded in the teacher's notebook by time period, duration and reason. It was relatively easy to obtain the duration and time period of instances of absenteeism by transferring this information from the teachers notebooks to the data entry sheet. The reason for an instance of absenteeism however, was not often recorded and thus gathering this data required a combination of the teacher's notes, the teacher's recall of the event in question, and quite often the aid of students within the classroom. Cases where students did not complete the school year were noted anecdotally (*traslado*) in place of further absenteeism information, in the row reserved for that student's information.

Instances of absenteeism were recorded on the data entry sheet by entering a single digit (1-8) for each day of absenteeism in the box corresponding to the month in which the absenteeism took place. The number chosen to represent each day of absenteeism corresponds to the reason for each instance of absenteeism, which is indexed as shown in Table 5.1. Thus, absenteeism for a student who missed three days of school in June due to malaria is represented by three consecutive ones [1,1,1] in the row associated with the student, and the column corresponding to the month of June.

Further clarification of the time period for each instance of absenteeism, for instance by week or specific day, would clearly be more informative. However, it is often not possible for teachers to recall the specific dates of instances of absenteeism that occurred many months previous to the time of the interview, and additionally the time required to record every absence by specific date would make the interview restrictively long. Finally, in cases where students dropped out, or changed schools, the approximate date of their departure from the current school was noted if possible on the data entry template.

Category	Reason	Description
1) Health-related	1) Infectious disease	Malaria, Dengue, Yellow fever, etc.
	2) Corporeal	Diarrhoea, food poisoning, illness from contaminated food or water, etc.
	3) Cerebral	Fever, headache, etc.
	4) Other health-related reason	Cold, flu, etc.
2) Non-health related	5) Work	Child or youth labour
	6) Economic	Cannot afford uniform, supplies, or transportation, user fees, etc.
	7) Environment	Cannot travel to the school due to weather-related conditions
	8) Social	Death in the family, other non-economic reasons for keep child from school

Table 5.1 – Index of reasons for absenteeism

The interviews resulted in over 300 handwritten pages of absenteeism data. Before these data were available for analysis, however, they had to be converted into a format compatible with the s-EMIS developed in this thesis. The first stage of this process required entering the information on the hand-written forms into a series of tables in a simple relation database using the model shown in Figure 5.2. The data entry model was designed to minimise data entry time by giving each phenomena in the data entry process an integer code in place of its representative text. For example, in the data entry model each reason for absenteeism is coded one through eight in place of entering the name of the reason each time the data are entered. The same process was used for categories of absenteeism (1-2), months (1-12), schools (1-41), and students (1-6,297). Indexing phenomena in this way is accomplished using lookup tables (LUT) as shown in Figure 5.2.

The second stage of this process required data pre-processing including aggregation of the sample data to the school level and standardisation of the absenteeism data. Aggregation of the raw absenteeism counts to the school level was accomplished using standard query language (SQL) queries performed on the data entered in to the absenteeism data model. Using SQL it is possible to return specific values of interest from a database based on pre-selected criteria and limitations. For example, the query used to return the total counts of absenteeism for the students at each school has the form:

```
SELECT [School ID], Sum([Duration]) FROM [Absenteeism]
GROUP BY [School ID]
```

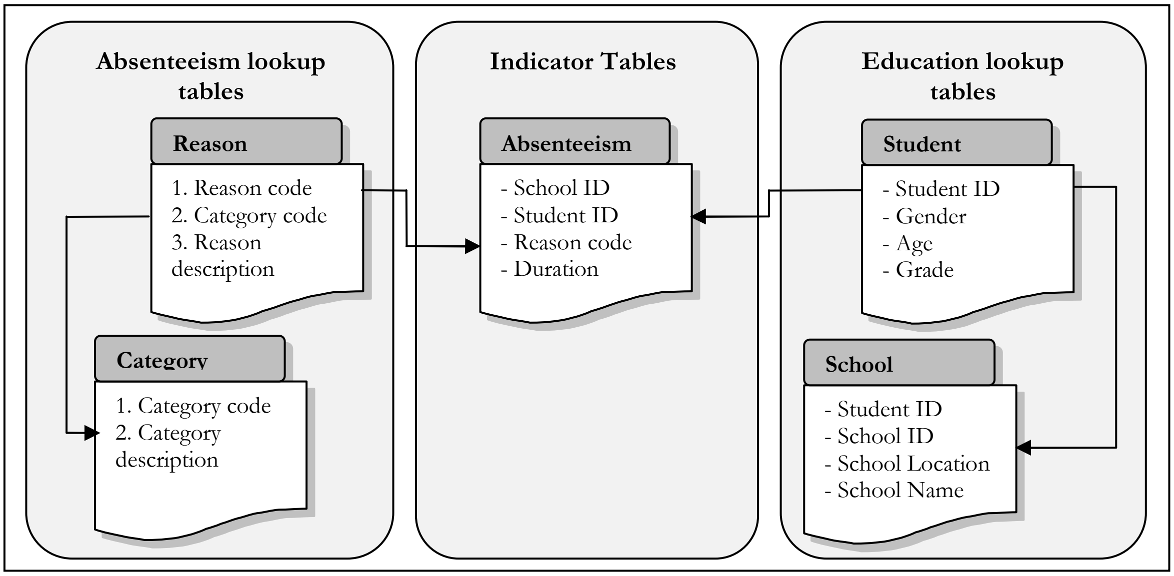


Figure 5.2 – Model for absenteeism data entry

This basic query can be extended to sum the days of absenteeism at each school by the internal characteristics of the data, such as the age, grade and gender of the student, as well as the category and reason for the absence. For example, the query to sum the total absences of females in grade six has the form:

```
SELECT [School ID], Sum([Duration]) FROM [Absenteeism]
GROUP BY [School ID] WHERE [Grade] = 6 AND [Gender] =
“Female”
```

Summing absenteeism for all males at a school separately from females is critical to the analysis in this thesis as it allows for gender-based analysis of the local effects of absenteeism. The same argument holds true for independent summations of the student sample data by their other internal characteristics such as age and grade, as well as for the reasons (and categories) of absenteeism. These four dimensions (note that the category of absenteeism is an aggregation of the reason for absenteeism) of the absenteeism data must be analysed independently and in conjunction with each other in order to understand all aspects of absenteeism at the local level. In total these four dimensions result in a set of 227 indicators (that measure different aspects of absenteeism), shown in Table 5.2, for the analysis of absenteeism at the school level.

However, assessing absenteeism at the school level from the total count indicators described above is not appropriate for two critical reasons. First, as discussed, not all students were sampled at all schools (samples at the schools ranges from 13.42% to 100% of the student population). Thus the sample of days of absenteeism taken at each school, which can be considered representative of the absenteeism for the entire student population at the schools (i.e., teachers were chosen at random to represent each grade equally as described previously), must be projected to represent the absenteeism for the entire school population. Second, not all schools have the same number of students. Clearly, accounting for student population size is important, as 100 total days of absenteeism among the student population will have a different overall effect on the educational experience at a school with a population of 50 students compared to a school with a population over 1,000 students.

Name of Indicator	Number of Indicators
Total absenteeism	1
Gender-based absenteeism	2
Grade-based absenteeism	6
Reason-based absenteeism	8
Category-based absenteeism	2
Gender and grade-based absenteeism	12
Grade and category-based absenteeism	12
Grade and reason-based absenteeism	48
Gender and reason-based absenteeism	16
Category and grade and gender based absenteeism	24
Reason grade and gender-based absenteeism	96

Table 5.2 – Absenteeism indicators

In order to address these issues the student sample and absenteeism count data must first be projected to represent the student population at each of the sampled schools. Projection of the student sample data was accomplished using equation 5-1 as shown below. This equation calculates the total number of students in the population for a given grade and/or gender category (i.e., all males, all grade 6 females, etc.) based on the known population of the school (taken from the 2005 *Padrón*).

$$Students[Category_x]_p = \frac{Students[Category_x]\left[School_y\right]_s \times Students\left[School_y\right]_p}{Students\left[School_y\right]_s} \qquad 5\text{-}1$$

Where:
p is the population,
s is the sample,
$Category_x$ is one of the categories of students (divided by grade and/or gender), and
$School_y$ is of the 35 sampled schools included in the analysis

The formula used to calculate the projected days of absenteeism at the school level for each of the 227 indicators is shown in equation 5-2. The formula calculates the expected days of absenteeism for the cohort of each school population that are included in the definition of the absenteeism indicator under consideration. For example, calculating the days of absenteeism for the population of females at each school requires inputting the sampled number of days of absenteeism for females, the number of sampled females and the number of females in the school population.

$$Days[Category_x]_p = \frac{Days[Indicator_x][School_y]_s \times Students[School_y]_p}{Students[School_y]_s} \qquad \textit{5-2}$$

Where:
p is the population,
s is the sample,
$Indicator_x$ is one of the 227 indicators, and
$School_y$ is of the 35 sampled schools included in the analysis

Standardising the counts of days of absenteeism against the student population is required for comparisons of absenteeism between schools with different population sizes. The standardisation calculation, shown below in equation 5-3, uses the projected student and absenteeism counts and returns a value which represents the expected number of days of absenteeism for students in each category (gender and/or grade) at each sampled school.

$$Absenteeism[Category_x]_p = \frac{Days[Category_x]_p}{Students[Category_x]_p} \qquad \textit{5-3}$$

Where:
p is the population, and
$Category_x$ is one of the categories of students (divided by grade and/or gender)

The final step in the process involved adding the new set of 227 indicators to the s-EMIS. This was accomplished by appending new columns to the school-level education indicator table rather than creating new relations. Wide tables (i.e., more columns) are generally preferred in hierarchical databases as they enhance database performance and reduce data processing time within the s-EMIS. Again, SQL was used to perform the vertical merge of the 60 columns in the absenteeism indicator table to the existing school-level indicator table. New columns can be appended to an existing table using a vertical merge function which orders the columns of each table included in the function on a specified field (in this case the school identifier) so that the values for each feature in the two tables become associated with the same feature after the merge. The result is a single wider table that contains not only the MINEDU education-based indicators, but also the absenteeism indicators created for the analysis in this thesis.

5.2.2 Analysis of the Absenteeism Sample Data

The end result of the interviews conducted with the teachers was detailed absenteeism information (time period, duration and reason) as well as detailed characteristics (age, grade and gender) for a sample of 6,297 students within the study area. Overall 32% of the students at the 41 sampled schools, and 19% of the total public primary school population at the 128 schools reporting data in the study area are represented in the data resulting from the teacher interviews. Disaggregation of the sample by the recorded characteristics shows that the data are as representative of the population as they can be, given limited knowledge about the overall characteristics of the primary student population in the study area.

For instance, disaggregating the sample of students by gender shows that there is an apparent under-representation of females (only 46% of the sample). Expressed as a ratio the sample has a female to male ratio of 0.84 (84 females for every 100 males). Aggregated across all primary grades the MINEDU *Censo Escolar* (2004) female to male ratio echoes the bias toward males in primary education, with a value 0.97 (97 females for every 100 males) in the province of Maynas. Further disaggregation of the MINEDU data by grade level, however, as shown in Figure 5.3, reveals discrepancies in the data that are the result of erroneous reporting of the data or errors in the data conversion and entry process.

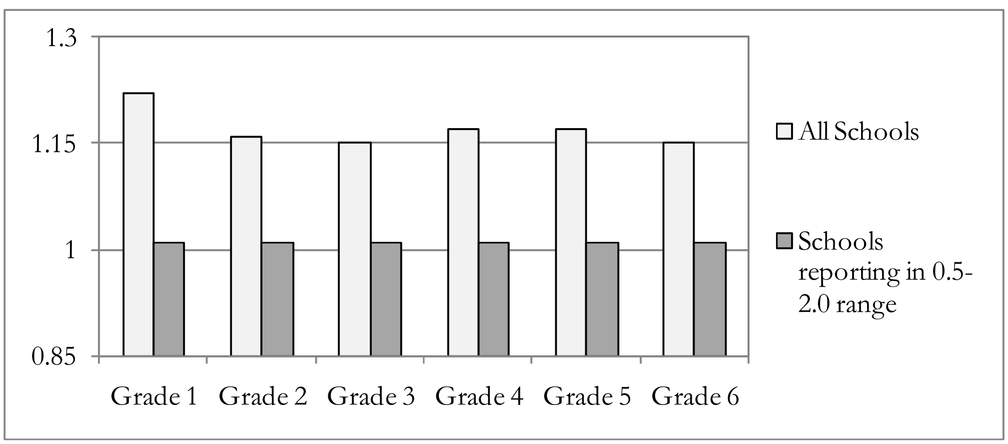


Figure 5.3 – Ratio of females to males by grade in the Province of Maynas (2004)

For example, the per-grade female to male ratios provided by the MINEDU suggest that there are more females enroled at each grade in the primary education system in Maynas, which runs counter-intuitive to the 0.97 value for the overall female to male ratio. This apparent discrepancy between the overall ratio (favouring males) and the per-grade ratio (favouring females) can, however, be corrected by removing errors from the database. These errors are errors both of omission and of commission. On average, 10% of the schools in the Province of Maynas did not report data for the per grade female to male ratios. In addition, values for the female to male ratio indicators range from as low as 0.09 to as high as 12, suggesting either 9 females for every 100 males, or 1200 females for every 100 males.

Empirical observation at the schools, however, reveals that there are no all-male or all-female public primary schools in the province of Maynas. Thus, the chances of such extreme values for the indicator or that there are even twice as many students of a particular gender in the student population are extremely low. The exception perhaps would be very small rural single-classroom schools, although this was not observed during the teacher interviews. Given these empirical observations, values for the female to male ratio below 0.5 (twice as many males) and 2.0 (twice as many females) may be considered erroneous and are likely due to erroneous data entry either at the school level or at the UGEL and DRE level. An analysis of the female to male ratio at each primary grade, with null and erroneous values outside the empirically observed range removed, as also shown in Figure 5.3 reveals much broader agreement with the overall female to male ratio in the 2004 MINEDU data, and reinforces the slight bias towards males in the sample.

The sample can also be disaggregated by grade and student age, as shown in Figure 5.4 and Figure 5.5. An even distribution of the sample by grade is important for the analysis of attrition and grade repetition that is discussed in Chapter 6. For the purposes of the discussion here, it is sufficient to show that the sample is fairly evenly distributed over this characteristic, with less than two percent difference in total representation between the least and most sampled grades. The student age disaggregation reinforces the bias towards male students discussed above. Overall, disaggregation by this characteristic is the least informative, as the most recently supplied population data from the INEI are from 1993, and are not available at a low enough level to either support or refute the age distribution in the sample collected.

An immediate policy implication of the data shown in Figure 5.5, however, is the apparent problem of over-age students in the primary education system. The presence of students above the age of 12 or 13 should be considered immediately problematic given that the primary education system enrols students at around age six and comprises six grades of study. As can be seen in the figure the sample contains students up to five years beyond this horizon, divided fairly equally by gender.

This section has described a spatially-based hierarchical data model (i.e., an s-EMIS) for the analysis of education quality, and populated it with existing data from the MINEDU and the INEI. As well, a new indicator of absenteeism was defined, collected and added to the s-EMIS after pre-processing and aggregation to the school level. The data that represent real world features within the s-EMIS, namely schools, city blocks, and population centres are now ready to be linked to the geographic locations which they describe using GIS. As noted earlier, these data may be aggregated to represent successively larger areas of the country (districts, provinces, and departments), however local level spatial analysis allows problem areas to be diagnosed more rigorously and remedial action plans to be put in place that are sensitive to widely differing local needs. The next section discusses common spatial analytical techniques that can be used at the local level to analyse spatial relationships in point patterns representing the schools in the study area.

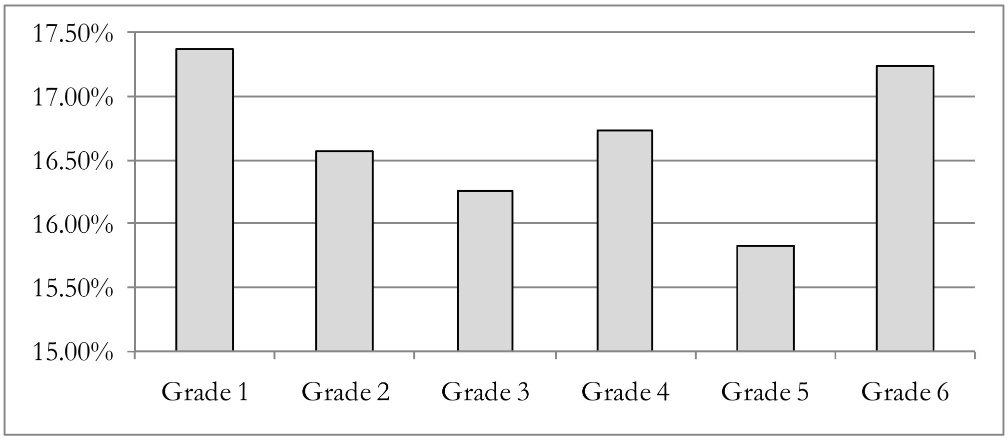


Figure 5.4 – Distribution of the student sample by grade

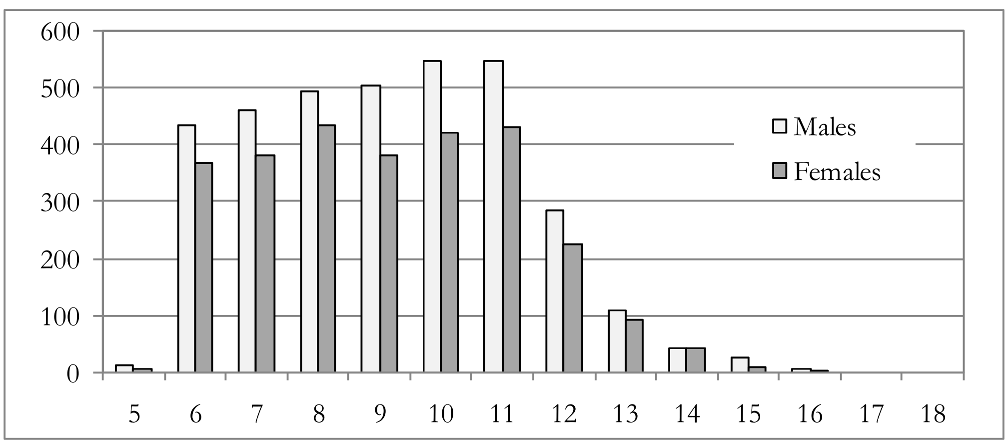


Figure 5.5 – Distribution of the student sample by age

5.3 Spatial Analytical Methods

Spatial statistics describes a family of statistical methods which study features using their topological, geometric or geographic properties (Haining, 2003). Spatial analysis of education systems can reveal the complex relationships between the education-based indicators and the socio-economic context indicators that make up the five components of the education model discussed in Chapter 2. Unfortunately, relatively few studies have incorporated a spatial analysis of the effect of socio-economic contextual factors on education quality despite the fact that socio-economic context has long been recognised as having an impact on the experience of the education received at school (Bradford, 1991, Özmert et al., 2005, Peters, 2002, UNESCO, 2005c). This understanding suggests that the effects of home-based characteristics such as access to water and electricity, along with relative family well-being, are effectively taken with the student to school each and every day. The following sections introduce and discuss several spatial analytical methods that can be applied to the features in the s-EMIS to evaluate these spatial relationships.

5.3.1 Cluster and Spatial Autocorrelation Methods

Some of the more common methods for analysis of spatial patterns, listed in Table 5.3, involve various approaches to analysing the spatial distribution of points. The most popular of these methods typically involve point pattern, and/or spatial autocorrelation analysis. Point pattern analysis is used to determine whether the spatial distribution of points is random or not, whereas spatial autocorrelation is concerned with whether points with similar characteristics tend to be closer to each other spatially than would be expected by random chance (Boots & Getis, 1988). These methods provide numerical statistics that can be used to gain further insight into the patterns that exist within the data, much the way normal statistics can be used to describe patterns observed within aspatial data. Some of these methods describe the spatial properties of an entire dataset, and generate a single global statistic, while other methods describe the local-level variability of these spatial properties within the data, thus allowing for multiple levels of spatial analysis (Fotheringham, Brundson & Charlton, 2002).

Spatial analytical methods can be used to generate either global or local statistics. A global statistical test produces a single numerical value that describes one aspect of the spatial properties of an entire dataset. Local statistics, on the other hand, describe the variability of spatial relationships within and between the features in the dataset and generate a statistical value for each feature in the dataset that describes its spatial dependence on its neighbours. Global statistics are of limited interest for much the same reason that aggregated indicators are considered limiting with respect to traditional statistical analyses. Global statistics can, however, provide a framework for exploratory analysis of spatial data within which more exploratory local analyses can be undertaken (Diggle, 2003). Global statistics are also helpful for the interpretation of local statistics.

One of the most commonly used global spatial statistics is the test for complete spatial randomness (CSR). Rejection of CSR for a set of discrete observations, in this case points representing schools, distributed over geographic space is considered to be a prerequisite to any serious attempt to analyse further observed patterns within the data (Diggle, 2003). A set of observations that do not exhibit CSR can be either regularly distributed or aggregated (clustered), as shown Figure 5.6. A regular pattern of observations is non-random in its distribution, yet the average distance between neighbours is similar for all points in the dataset (i.e., the points exhibit no clustering). Clustered patterns occur when many observations are concentrated close together and there are areas within the study region that contain very few, if any, observations. Although point patterns can often be determined from visual inspection, statistical tests for CSR provide more meaningful insight into the underlying distribution of the points and provide the statistical significance required to perform further tests on the dataset (Diggle, 2003).

Method	Type	Purpose and Characteristics
Empirical Distribution Function (EDF)	Visual interpretation	Plots the proportion of nearest neighbour pairs whose distance is less than or equal to a given threshold; the shape of the plot can be used to determine if the data are spatially clustered, random or regular.
Test for Complete Spatial Randomness (CSR)	Global test for spatial clustering or regularity	Calculates the statistical difference of the average nearest neighbour distances in a dataset to an expected average under theoretical CSR. Significant negative t-statistic indicates clustering; significant positive t-statistic indicates regularity; insignificant t-statistic indicates CSR.
Moran's I	Global spatial autocorrelation	Detects global spatial autocorrelation of a variable. Values of I range from -1 to 1close to -1; values of I closer to -1 indicate dispersion; values close to 1 indicate spatial autocorrelation; values close to 0 indicate randomness.
Getis-Ord G	Global spatial autocorrelation	Detects whether high values or low values of a variable tend to be spatially clustered globally. Significant lower than expected values of G indicate clustering of low values of the measured variable; significant high values of G indicate clustering high values of the variable.
Local Moran's I_i	Local spatial autocorrelation	Detects variability of spatial autocorrelation of a variable at local scales. Significant high values indicate local spatial autocorrelation for the variable a given feature; significant low values indicate dispersion of the variable at a given feature.
Local Getis-Ord G_i	Local spatial autocorrelation	Detects local clusters of high or low values of a variable. Significantly higher than expected values of G_i indicate local clustering of high values of the measured variable at a given feature; significantly lower than expected values of G_i indicate local clustering of low values of the measured variable.
Geographically weighted regression	Local regression parameter estimation	Estimates spatially weighted regression parameters; detects variability of relationships between a dependant and one or more independent variables by estimating regression parameters at each feature in the dataset.

Table 5.3 – Methods used for exploratory analysis of spatial data
(Adapted from Leahy, 2005)

Tests for CSR typically employ either quadrat analyses or distance-based measures in order to assess the hypothesis that a finite set of points in a bounded sampling window are randomly distributed (Diggle, 2003, Chen & Getis, 1998, Griffith, 1987). A quadrat is a geographical sampling sub-unit which is usually rectangular. Quadrat analysis is severely limiting, however, because summarising the point pattern as a set of frequencies (counts of points in each quadrat) loses the spatial dimension of the pattern. Quadrat analysis is therefore more a measure of spatial dispersion, rather than spatial patterns, because it is based primarily on the density of points and not their arrangement in relation to one another across geographic space (Boots & Getis, 1988). Using quadrat analysis different point patterns it is possible to produce identical CSR test results for different study regions in cases where the frequency of quadrats with the same density of points is similar, regardless of the actual distribution of points within each study region. This demonstrates that quadrat analysis is insensitive to the spatial arrangement of the quadrats and thus requires an additional statistical procedure to determine the presence of CSR (Boots & Getis, 1988).

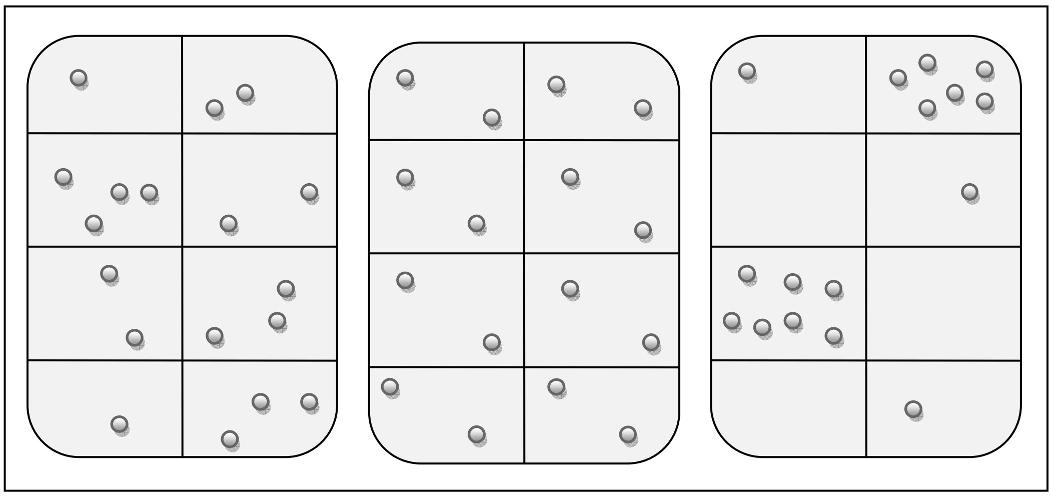


Figure 5.6 – Random, regular and clustered point patterns

A distance-based test for CSR within a dataset can be informally assessed by plotting an empirical distribution function (EDF) which tests the nearest neighbour distance for each point in the set against the maximum nearest neighbour distance. The EDF plots the distance to the nearest neighbour (expressed as a percentage of the maximum nearest neighbour distance) versus the percentage of points sharing a similar nearest neighbour distance, as shown in Figure 5.7. Visual inspection of the plot can reveal empirical spatial dependency in the point distribution. On the EDF plot CSR appears as a positive linear relationship where the proportion of points with nearest neighbour distances below a given threshold is proportional to the threshold distance. Regular or clustered distributions appear as asymptotic curves, where a sharp rise in the proportion of points that are co-located with their nearest neighbours (i.e., a low nearest neighbour distance) indicates that the distribution of the points is clustered. An asymptotic curve indicates a regular non-random distribution of points.

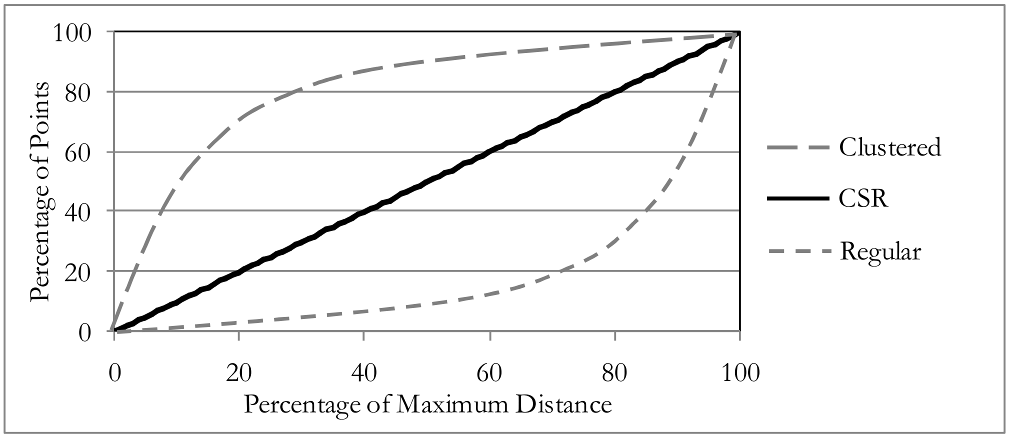


Figure 5.7 – Plot of the empirical distribution function

Statistical evaluation of CSR requires determination of the mean nearest neighbour distance for all points across the study region. This mean is then tested against the expected average and the expected variance of the individual nearest neighbour distances of the points using the normal distribution (Donnelly, 1978). The equations for the expected average and the expected variance respectively are shown in equations 5-4 and 5-5. The constants used in these equations have been shown over exhaustive empirical testing to produce a good approximation of the expected average and variance under CSR regardless of the size or shape of a given study region (Diggle, 2003). These equations also contain a correction factor to account for the boundary effect (Donnelly, 1978).

$$E[\bar{y}] = \frac{1}{2}\sqrt{\frac{A}{N}} + \left(0.0514 + \frac{0.041}{\sqrt{N}}\right)\frac{P}{N} \qquad \textit{5-4}$$

$$\mathrm{Var}[\bar{y}] = 0.07\left(\frac{A}{N^2}\right) + 0.037P\sqrt{\frac{A}{N^5}} \qquad \textit{5-5}$$

Where:
A is the area of the study region,
P is the perimeter of the study region, and
N is the total number of points to be considered.

A Z-score can be calculated from the expected average and expected variance as shown in equation 5-6. Rejection of the null hypothesis (i.e., determination that the points are not randomly distributed) occurs when the Z-score is significantly large. A positive and significant Z-score implies a regular spatial pattern and a negative and significant Z-score implies a spatially clustered point distribution. As noted, the points in the study region should be distributed non-randomly (i.e., either regularly distributed or clustered) in order to perform further exploratory and evaluative spatial analyses (Donnelly, 1978).

$$z = \frac{[\bar{y}] - E[\bar{y}]}{Var[\bar{y}]} \qquad 5\text{-}6$$

After a test for CSR is conducted, it is possible to apply tests of spatial autocorrelation to the points in the study region. Prior research has suggested that education quality in schools is affected by their surrounding socio-economic, political, and environmental (i.e., their spatial) contexts (Flowerdew & Pearce, 2001, Leahy, 2005, Peters, 2002). Absenteeism, as a proxy for the effect of socio-economic context on the experience of education provided at schools may be affected in a similar fashion. This argument leads logically to the expectation that the characteristics of, and the levels of absenteeism experienced, at any particular school is more likely to be similar for schools situated near to each other than for schools located further away. In other words, there is an intuitive expectation that contextual factors, namely socio-economic and environmental conditions, are spatially autocorrelated and that even for regularly distributed school locations there may be an underlying clustering of schools based on their characteristics as measured by the s-EMIS indicators described previously.

Autocorrelation is defined as the relationship among values of an indicator that is attributable to an underlying ordering of these values, whether that underlying order is dependent on either temporal or spatial sequencing (Griffith, 1987). For time-series data the underlying ordering pattern of the values of the indicator follows the sequence in which the data for the indicator were collected. Spatial autocorrelation is similar conceptually with spatial processes used instead of temporal processes. For example, in spatial autocorrelation the ordering pattern of the indicator data for each school is based on the geographic location of the schools relative to their neighbours. This ordering may be represented conceptually as a contiguity matrix of n-by-n dimensions (where n represents the number of point features to be considered) in which the columns and rows are arranged in ascending order based on features that are considered neighbours within geographic space (Diggle, 2003).

This arrangement produces multiple and overlapping pairs of points which can be assigned a value that represents spatial dependency. The assigned value can be either binary, corresponding to whether or not the points are neighbours, or weighted corresponding to the strength of the spatial dependency of the points. Evaluation of spatial autocorrelation using a contiguity matrix places the focus of the evaluation on the spatial relationships between school locations and disregards the arbitrary order in which they may be listed in the dataset (Diggle, 2003). Once the spatial ordering of the school point locations in the contiguity matrix has been determined, the next step is to verify statistically the presence of spatial autocorrelation within the dataset. There are a number of different approaches for testing spatial autocorrelation, including Moran's I and the Getis-Ord G statistic, which can be adapted to measure both global and local spatial autocorrelation (for local level spatial autocorrelation the statistics are notated as I_i and G_i). Global tests consider only mean inter-point distances and are referred to as first order tests, as opposed to second order local tests which consider all point-to-point distances (Boots & Getis, 1988).

The global Moran's I statistic, given in equation 5-7, is produced by standardising the spatial autocovariance against the statistical variance of the data. Autocovariance is the covariance of the recorded data value in a stochastic process measured against a time-shifted (or in this case geographically-shifted) version of itself. When normalised by dividing by the statistical variance, the autocovariance becomes the autocorrelation. Moran's I statistic returns values in the range negative one to positive one [-1 … +1], where the theoretical expected value of the statistic is negative one divided by one less than the number of points to be considered [-1/(N-1)] (Moran, 1950). Values for the statistic that *exceed* the theoretical expected value indicate positive autocorrelation and values for the statistic *below* the theoretical expected value indicate negative autocorrelation. A value of zero for the statistic indicates no spatial autocorrelation and this result should be viewed relative to the exploratory CSR evaluation of the points within the study area (Moran, 1950).

$$I = \frac{N}{S_o}\left(\frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}\left(x_j - \bar{x}\right)}{\sum_{i=1}^{N}(x_i - \bar{x})^2}\right) \qquad \textit{5-7}$$

$$\text{where: } S_0 = \sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij} \qquad \textit{5-8}$$

Where:
N is the total number of points to be considered,
x is the value of the indicator associated with points i and j, and
w_{ij} is the weight assigned to the pairing of points i and j.

The global Getis-Ord G statistic, given in equation 5-9, also measures spatial autocorrelation, however, it is a multiplicative measure of spatial association of the indicator values associated with discrete point locations which fall within a critical threshold distance of each other (Getis & Ord, 1992). The Getis-Ord statistic has the advantage of being able to distinguish between significant clustering of points with high indicator values (e.g., schools with high rates of absenteeism) and significant clustering of points with low indicator values (e.g., schools with low rates of absenteeism). These clusters are referred to as hot-spots and cold-spots respectively. The statistic is reported as a Z-score where a lower value corresponds to increased clustering of low indicator values in the dataset and a high value corresponds to increased clustering of high data values in the dataset. Significance of the test result is based on the confidence level chosen (i.e., at the 95% confidence level the G value would have to be less than – 1.96 or greater than 1.96 to be statistically significant).

$$G(d) = \frac{\sum_{i=1}^{N} \sum_{j=1, j \neq 1}^{N} w_{ij}(d) x_i x_j}{\sum_{i=1}^{N} \sum_{j=1, j \neq 1}^{N} x_i x_j} \quad 5\text{-}9$$

Where:
$w_{ij}(d)$ is the weight assigned to the pairing of points i and j for distance d.

While both the Moran's I and the Getis-Ord G statistics are useful for global analyses of point patterns and clustering they can only provide general descriptive statistics of the spatial configuration of the data. These global level analyses may mask local spatial processes and point configurations since they produce a single measure of spatial autocorrelation across an entire dataset (Boots & Getis, 1988). This leads to the conclusion of stationarity in the underlying point processes. Stationarity in stochastic spatial processes describes the situation where the distribution of points within various sub-sections of the study region appears to be the same everywhere yet do not exhibit CSR (Chen & Getis, 1998). This is shown in Figure 5.8. For example, if a moveable sample window were shifted to various locations within the study region, the pattern of the points observed within the sample window would look very similar. In contrast, datasets that have variable localised spatial relationships are referred to as non-stationary.

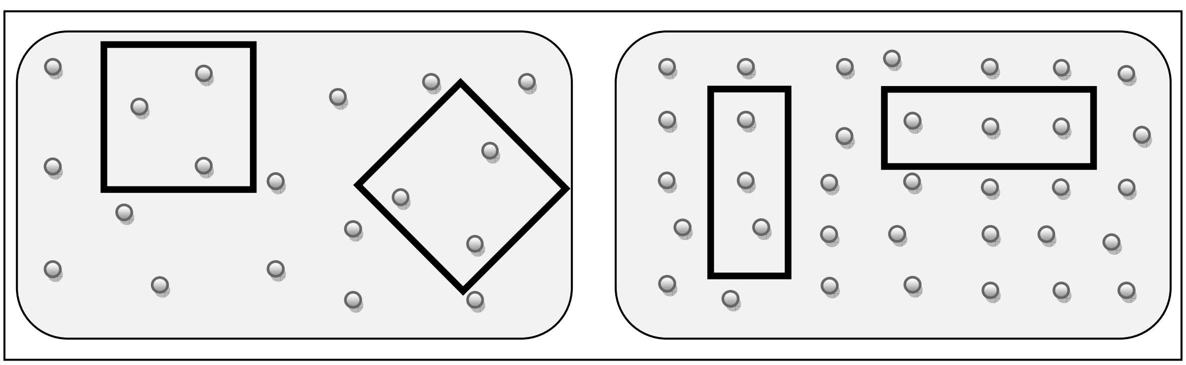


Figure 5.8 – Stationarity for sub-regions within a study region

However, not all spatial processes exhibit stationarity. Determination of the stationarity of spatial processes requires local spatial autocorrelation analyses. Consequently, both Moran's I (I_i) and the Getis-Ord G (G_i) statistics have second order measurements (Anselin, 1995, Getis & Ord, 1992). These second order statistics are calculated in the same way as the global statistics, however, they are calculated for each location in the dataset based on its spatial neighbours rather than for the entire dataset. These local level statistics can be used to detect the local spatial clustering around an individual location and to test for spatial non-stationarity (Chen & Getis, 1998). For example, Moran's I_i, calculated based on equation 5-10 is useful for identifying local areas where there is significant positive or negative autocorrelation in point distributions (Anselin, 1995). Furthermore, the G_i statistic, calculated based on equation 5-11, can be used to identify areas of high spatial autocorrelation for high and low values of an indicator (Getis & Ord, 1992).

$$I_i = \frac{x_i - \bar{x}}{S^2} \sum_{j=1}^{N} w_{ij} \left(x_i - \bar{x} \right) \tag{5-10}$$

$$G_i(d) = \frac{\sum_{j=1}^{N} w_{ij}(d) x_j - \bar{x} \sum_{j=1}^{N} w_{ij}(d)}{S \sqrt{\frac{N \left[\sum_{j=1}^{N} {w_{ij}}^2 (d) - \left(\sum_{j=1}^{N} w_{ij}(d) \right)^2 \right]}{N-1}}} \tag{5-11}$$

$$where: S = \frac{\sum_{j=1, j \neq 1}^{N} x_j^2}{N-1} - x^2 \tag{5-12}$$

Where:
N is the total number of points to be considered,
x is the value of the indicator associated with points i and j, and
w_{ij} is the weight assigned to the pairing of points i and j

The advantage of using local tests is that much more detailed information about the underlying point processes is returned. In addition, for datasets that exhibit high spatial autocorrelation the global and local Getis-Ord tests may return different results. For example, the global G statistic will often not detect significant patterns, such as statistically significant concentrations of high or low values, in highly autocorrelated point processes that can be revealed by the local level test (Fotheringham et al., 2002). The final advantage of using local tests is that output produced from each of these tests allows the results of the calculations, as well as their statistical significance, to be viewed in map form using a GIS.

Due to the computational complexity of both the I and G statistics at the global and the local levels it is practical to automate the calculations using GIS software, such as ESRI's ArcGIS. This has the added advantage of allowing multiple trials to test the effect of selecting different methods, listed in Table 5.4, for conceptualising spatial relationships. The selection of this method is particularly important as it affects the way in which weights are calculated for each combination of neighbours in the dataset. The selection of the method is also dependant on the type of features that are being measured. For example, natural features such as clusters of plants or trees are usually measured using inverse distance (or inverse distance squared), whereas the geographic distribution of physical structures (such as schools) is most often measured using the zone of indifference or the fixed distance band methods. Incorrect assessment of the conceptualisation of the spatial relationships for the features under consideration can lead to over or under representation of the effect of neighbouring features (both co-located and dispersed) which can skew the results of the analysis.

In addition, the ArcGIS software package has two options for calculating distances, namely Euclidean and Manhattan distances. Euclidean distance measures the straight-line distance, or shortest path, between locations. The Manhattan distance, on the other hand, is an approximation of distance between locations measured along axes at right angles to the Euclidean distance path. This measure of distance is representative of the impediment created by city blocks.

Method	Features	Description
Inverse Distance	Points, polygons	The impact of one feature on another feature decreases in a linear fashion with distance.
Inverse Distance Squared	Points, polygons	The impact of one feature on another feature decreases according to the square of the distance between them.
Fixed Distance Band	Points, polygons	Everything within a user-specified critical distance is assigned a weight of one; everything outside the critical distance is excluded from the analysis.
Zone of Indifference	Points, polygons	A combination of the Inverse Distance Squared and the Fixed Distance Band methods. All features up to a critical distance are assigned declining weights. Once the user-defined critical distance is exceeded, the weights decline rapidly to zero.
Polygon Contiguity	Polygons (first order)	The neighbours of each feature are only those with which the feature shares a boundary. All other features have no influence.

Table 5.4 – Methods for conceptualising spatial relationships
(Adapted from ESRI, 2007)

In summary, tests for CSR and spatial autocorrelation are useful for analysing the spatial patterns and spatial dependence of discrete points distributed over geographic space. However, identification of a spatial pattern in a set of distributed points cannot explain by itself the causal processes that produce these patterns. For example, identification of a cluster of schools exhibiting high levels of absenteeism using Moran's I or the Getis-Ord G statistics cannot tell an education planner the reason for this clustering. Determination of cause requires evaluating the contributory causes to absenteeism using a set of explanatory variables measured against the observed spatial point pattern. This can be accomplished with geographically weighted regression based on multivariate spatial data, as explained in the following section.

5.3.2 Geographically Weighted Regression

In traditional statistics, determination of causation is achieved using ordinary least-squares (OLS) regression methods. The OLS regression model is used to describe the strength and direction of relationships between a dependent variable and a set of explanatory (independent) variables. The OLS model produces a fit line for a plot of the dependant variable (y axis) versus each independent variable (x axis) such that the squares of the residuals (i.e., the distance from each point to the fit line) are minimised. In this way OLS models explain the variance in the dependant variable and can be used for prediction via extrapolation of the value of the dependent variable beyond the empirically collected observations. For example, the absenteeism data collected for this thesis may be considered a dependant variable that can be plotted against a set of indicators measuring the five components of the education system. The OLS model, however, is akin to the calculation of global statistics that must assume stationarity within the dataset, and as such is limiting with respect to exploration of spatially-based data. This is because the relationships determined by OLS are assumed a priori to be equally applicable to all geographic locations.

Geographically weighted regression (GWR) can be conceptualised as a spatial extension of the ordinary least squares (OLS) regression model. The GWR equation is a form of second order spatial autocorrelation tests that does not assume stationarity within the underlying points and thus can be used to determine the intervening variables that contribute most to clustering and the production of either hot or cold spots exhibited in the underlying point pattern. The first step of the analysis is to define a series of regression points within the bounded sample region. These regression points are generally constructed by placing a grid over the study region where regression points occur at the intersections of the grid lines, as shown in Figure 5.9. The GWR model is then calibrated using an adaptive spatial kernel with bandwidth inversely proportional to the density of the data points (Fotheringham et al., 2002). All data points within this kernel are weighted based on their distance from the regression point. Thus, the weight assigned to data points is highest at each regression point and decreases continuously as the distance from the regression point to data points increases.

Essentially, GWR allows each of the parameters estimated in the regression model to vary over space (Fotheringham et al., 2002). The results of each individual local regression are then combined and can be viewed on a map as a surface of parameter estimates that are locally sensitive to the spatial distribution of the points as well as the multiple variable values at each point. Using this approach, it is possible to evaluate the relative importance of the parameter estimates at specific locations within the study area. The advantage of using GWR is that it may be able to explain the cause of clustering within the dataset. For example, where clusters of schools with high or low levels of absenteeism have been identified with spatial autocorrelation tests, GWR analysis can explain the occurrence of these patterns by analysing the contribution of individual variables to the clustering. This knowledge can have significant utility for education policy planners and decision-makers attempting to improve the situation of absenteeism with locally sensitive initiatives.

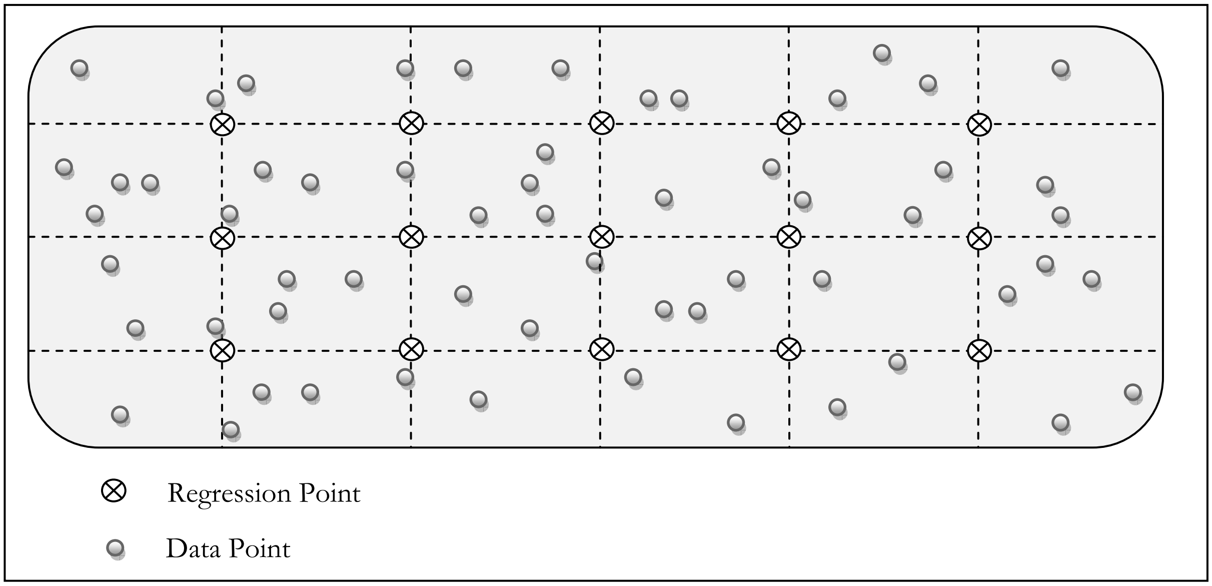


Figure 5.9 – Location of regression points

5.4 Summary

This chapter has described and developed an s-EMIS that can be used to evaluate both education quality and the effect of absenteeism on education quality at the schools in the province of Maynas. A set of absenteeism indicators were also defined, and a methodology for the collection of these data was established. The method for adding these new indicators to the s-EMIS followed. The final section presented a range of methods that can be employed to analyse the spatial distribution of absenteeism by taking into account the spatial properties of the data (i.e., the location of the schools) that were collected for this thesis. The following chapter demonstrates the use of these methods and discusses the data pre-processing required to populate the s-EMIS with school-level data in support of an evaluation of education quality and the effect of absenteeism on the quality of education delivered at schools.

Chapter 6

Statistical and Spatial Analysis of Absenteeism

This chapter presents a statistical analysis of the student absenteeism data as well as the implementation of the spatial analytical methods described in Chapter 5. The first section discusses the data pre-processing required on the data before the statistical and spatial analyses could be conducted. This pre-processing first required developing a methodology for the aggregation of socio-economic indicators from population centres and city blocks to the school level. Once the aggregation was completed it was possible to develop statistical models to assess education quality at all schools using MINEDU and INEI data and also to predict absenteeism at non-sampled schools in the study area. The second section of the chapter presents the results of the statistical and spatial analyses performed on the observed and predicted absenteeism data with respect to education quality. These results are presented along with a discussion of how they can assist education planners to understand how absenteeism may be reduced at the school level and how the effects of absenteeism may be mitigated through planned interventions.

6.1 Data Pre-processing

Spatial analysis of education systems can reveal the complex relationships between the education-based indicators and the socio-economic context indicators that make up the five components of the education model discussed in Chapter 2. Unfortunately, relatively few studies have incorporated a spatial analysis of the effect of socio-economic contextual factors on education quality despite the fact that socio-economic context has long been recognised as having an impact on the experience of the education received at school (Bradford, 1991, Özmert et al., 2005, Peters, 2002, UNESCO, 2005c). This understanding suggests that the effects of home-based characteristics such as access to water and electricity, along with relative family well-being, are effectively taken with the student to school each and every day.

In addition, analysis of education-based and socio-economic indicators is best conducted at the local level, in this case at the level of individual schools. Education-based indicators in the s-EMIS described in section 5.1 are already aggregated to this level, as this is the level at which they were initially reported to the MINEDU. The indicators provided by the INEI, however, are aggregated at various levels such as city blocks and/or population centres. These indicators must first be re-aggregated to the school level before they can be analysed in conjunction with the education-based indicators. Several methodologies can be used to accomplish this re-aggregation, all of which allocate the socio-economic characteristics of multiple city blocks or multiple population centres to school locations based on proximity and/or a proportional allocation rule.

Once all the indicators to be included in the analysis are aggregated to a common level, it is possible in principle to assess education quality using indicators from all five components of the education system model, as described in Figure 2.4. Aggregation of all indicators to the school level also makes it possible to predict absenteeism at non-sampled schools. The following sections describe these different processes and discuss the validity of the results.

6.1.1 Aggregation of Socio-economic Indicators to the School Level

The data model presented in Figure 5.1 represents the features at each level of aggregation as either irregular polygons or discrete points in space. Administrative boundaries are used to identify areas of influence for the administrative levels of the MINEDU as well as the INEI. Schools, on the other hand, are located by their street addresses and/or geographic coordinates which allowed them to be explicitly associated with surrounding neighbourhoods and communities based on spatial proximity. This approach, however, masks some of the complexity inherent in education systems. For example, parents do not necessarily send their children to the school that is closest to their home. In contexts where parents have a choice of schools and an accessible transportation network, settlement patterns, terrain, socio-economic opportunities and an opinion about the quality of teachers and/or the safety of particular schools all influence the choice of school.

In the larger urban centres in Peru, such as Lima and Cusco, distance is often a less critical factor due to the high density of schools as well as the availability of an accessible and affordable transportation network. In addition, there is a higher prevalence of private schools which tend to attract the more socio-economically advantaged students. However, in the city of Iquitos the reality is almost entirely the opposite. The residential density of Iquitos does not approach that of the larger urban centres, and the density of schools within the urban area is also much less. In addition, given the depressed socio-economic status of the city and the lack of a reasonable transportation network, parents are unlikely to have either the luxury or the opportunity to choose which school they wish their children to attend.

In spite of the concerns noted above, it should, in principle, be relatively easy to associate school locations with the home location of each student, since the student's home address is recorded upon her/his entry to the education system. There are, however, several technical barriers to this. First, although the *Ficha Unica del Alumno* (unique student registration form) contains address information for each student, these forms do not exist in digital format for most areas in the country, especially in Loreto and the other Amazonian departments. In addition, address information is likely to be inaccurate after several years, or may not even be applicable in many rural areas or in informal or squatter urban settlements where formal road naming and addressing conventions do not exist. This is especially true with respect to the remote areas surrounding Iquitos.

Furthermore, even for urban areas with established street naming and numbering there are no corresponding digital single line street network (SLSN) map layers available in compatible GIS format. A properly attributed SLSN contains line segments that represent the centreline of each street which is coded with the name of the street it represents, as well as the range of address numbers assigned to each segment. Using an SLSN, street addresses can be converted into point locations through a process known as geocoding. Without an SLSN, home locations would have to be plotted manually, based on a combination of local knowledge and best guesses.

Hence, alternative methods must be used to approximate the relationship between the location of a particular school and the area from which it draws its students. This area of influence, also known as a catchment, encompasses city blocks, neighbourhoods, communities, and/or population centres depending on the context of the school location. At the local level there are several methods that can be used to assign the socio-economic data from city blocks and/or population centres to the school location. These include, but are not limited to, nearest neighbour, constrained allocation, and both regular and weighted Voronoi methods. The nearest neighbour and regular Voronoi methods are distinct from the other two methods, in that they do not use disaggregated population data to define areas of influence over space. For these methods, the area of influence of a feature (in this case public primary schools) is determined based on spatial relationships only. Each of these methods is explained below.

The nearest neighbour method is based on the spatial proximity between the features in the socio-economic layers (whether irregular polygons representing city blocks or discrete points representing population centres) and the point features representing the school locations. The nearest neighbour function calculates the distance from each vertex (point of inflection) of the socio-economic features to each school location. In the case of population centres there is only one vertex, namely the point itself. Irregular polygons representing city blocks, on the other hand, are effectively represented as a series of points located at the vertices of the polygons. Nearest neighbour assignment, as the name suggests, uses a simple allocation rule based on shortest distance between features. City blocks and population centres are assigned to the 'nearest' school, where 'nearest' is defined as the school closest to one of the vertices of the city block or the point representing the population centre, as shown in Figure 6.1.

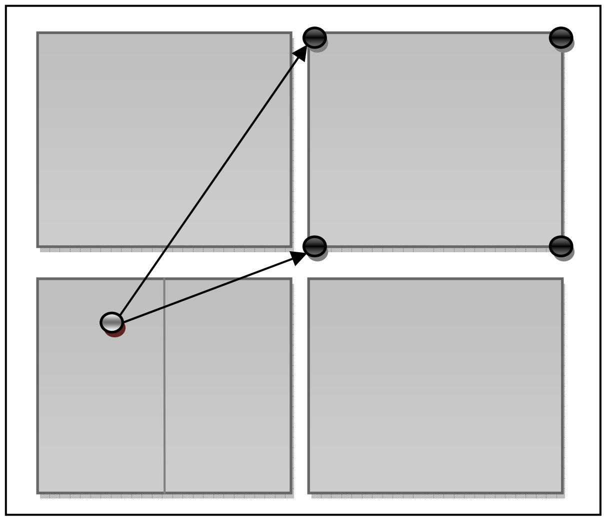


Figure 6.1 – Methodology for determining nearest neighbour

Figure 6.2 shows a nearest neighbour assignment of city blocks to schools in the city of Iquitos. In the figure all city blocks of one colour are assigned to the same school (shown along with their unique identifiers). While this allocation method does produce reasonable results it can be problematic where polygons are large relative to the density of the points. Since polygons are normally described by their vertices it is not easy to evaluate 'nearness' with respect to the boundary lines defining the polygons. For example, a school that is located very close to one of the boundary of a polygon, but far from any of its vertices is not considered 'near' using this method. A standard method for removing this source of error from the database is to generate pseudo-vertices at regular intervals along the boundary lines of the polygon. The drawback of this solution is an exponential increase in processing time as the number of points in the allocation function is increased.

The constrained distance allocation method extends the purely spatial approach of nearest neighbour assignment by taking into account the actual population of primary-age students in the city blocks and population centres relative to the enrolment capacity of individual schools and distance of population centres or city blocks from schools. The method employs an iterative process where each iteration begins with the temporary assignment of students living in urban city blocks or rural population centres in the study area to the nearest (by the same definition as described above) school. If the school has the capacity to accept the students then the students and the polygon or point they reside in is permanently assigned to the school and is not available for further allocations to other schools. The primary-age population from the polygons or points is added to an 'allocated' value associated with the school and the allocation iterations continue until all students are allocated to the nearest school and all schools are within or equal to their enrolment capacities. If all students are allocated to schools relative to school enrolment capacity and if unallocated students remain, there is excess demand in the system. If all students are allocated and schools still have not reached their enrolment capacity there is potential for growth in enrolment as the system is operating above its theoretical student capacity.

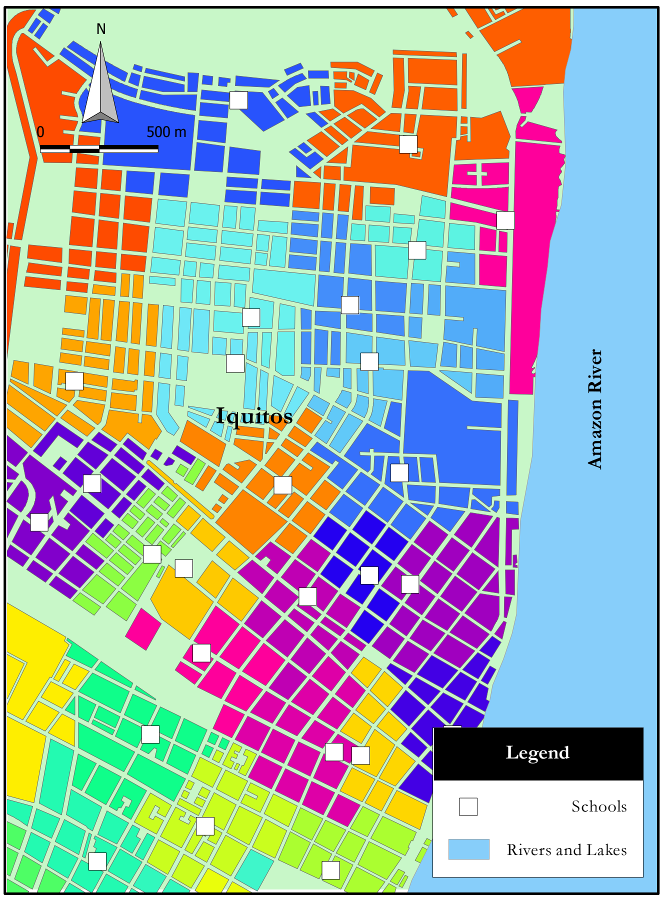


Figure 6.2 – Nearest neighbour assignment

The constrained distance allocation method is numerically accurate in that it is based on a simple accounting principle and it is also spatially reasonable in the case where distance is an important decision factor with respect to school choice. However, this method can lead to the production of outliers as students from more densely populated city blocks are assigned to schools at the edge of the study area, due to the overwhelming influence of densely populated city blocks filling the capacity of available schools in the core of the study area. The accuracy of this method is also clearly linked to the quality of the input data. For this thesis, as mentioned, the most current census data are from 1993. Associating 1993 census population data for students for city blocks and population centres with school capacity data from 2005 is clearly problematic. Hence, despite its computational robustness, this method was not used for the thesis.

The Voronoi and weighted Voronoi methods use a tessellation of points in planar space relative to bounding and space filling polygons where polygon boundaries are defined around the points such that each point is closer to the edges of the polygon that bounds it than to any other point on the plane. This useful property creates effective school catchments that can be used to assign city blocks and population centres to schools relative to the containment of one layer within the other. The unweighted Voronoi model makes a number of assumptions including the expectation that all families consider all schools equally satisfactory for their children, that there are no transportation barriers within the study area, and that all schools have the necessary capacity to satisfy the allocation of students from the assigned polygons. In contrast, the weighted Voronoi model allows the last constraint to be relaxed where schools with larger enrolments or capacities can have relatively larger influences on the allocation of students. The results of the unweighted and weighted Voronoi methods are presented as Voronoi diagrams (VD) or weighted Voronoi diagrams (WVD) respectively. A VD for the urban portion of the study area is shown in Figure 6.3 using a choropleth (a thematic mean of displaying discrete attribute values, or ranges of values, using different colours) where each colour represents a group of city blocks that are assigned to a single school.

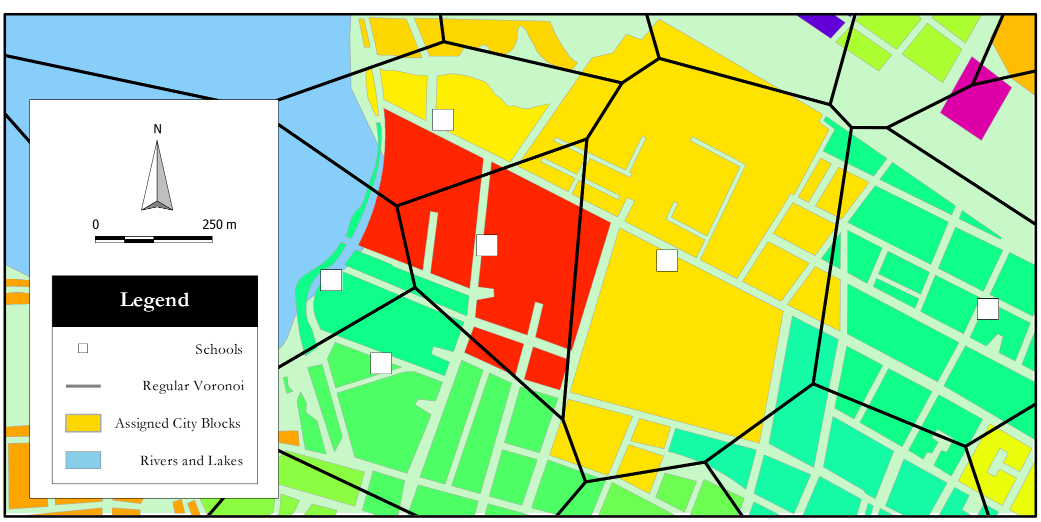


Figure 6.3 – Block assignment using regular Voronoi polygons

While most GIS packages can create VD, the creation of WVD requires the use of a custom software tool such as Gambini (Okabe et al., 1992). As noted above, a WVD determines the sphere of influence around the tessellation of points based on their relative capacities as well as their spatial relationships. Thus, the diagram can be regarded as the equilibrium of a wave diffusion process around the source points where the speed of spread outwards from each point is proportional to the relative importance (or weight) of each point (Okabe et al., 1992). A WVD for the same portion of the study area is shown in Figure 6.4.

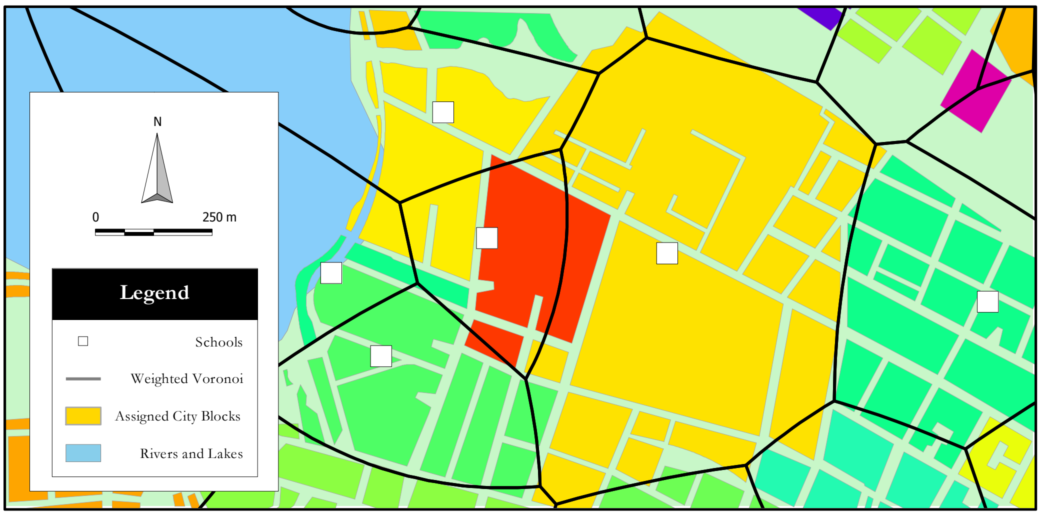


Figure 6.4 – Block assignment using weighted Voronoi polygons

For this thesis the weighted Voronoi method was used to allocate the city blocks in Iquitos and the surrounding rural population centres to public primary schools. City blocks were assigned to schools based on the weighted Voronoi polygon that contained both the geometric centroid of the city block and a school location point when the three layers (city blocks, schools, weighted Voronoi polygons) were overlaid in a GIS. Population centres were assigned using the same method, using their discrete point location in place of the geometric centroid of a city block.

Both procedures used the Contains function in spatial SQL. In spatial SQL, Contains has a specific meaning that sets it apart from Equals, Disjoint, Intersects, Touches, Crosses, Within or Overlaps. These are all examples of spatial SQL functions that are used to determine the spatial relation between two shapes. The definition of spatial SQL functions and how they evaluate the spatial relationship between shapes is set out in the Open GIS Consortium (OGC) Simple Features Specification for SQL (OGC, 1999). These functions accept two shapes as inputs and return a Boolean value when the relation of the first input shape to the second input shape meets the requirements of the function.

In the case of the Contains function, a Boolean value of true is returned when all the vertices and the resulting boundary of the first shape are entirely within and do not extend beyond or outside of the boundary of the second shape. The Contains function and the spatial SQL Centroid function (which returns the centroid of a shape) were added to a standard SQL update query that performed the spatially-based assignment discussed here. Two queries were used (one for city blocks and one for population centres since these features are stored in different layers) as:

```
UPDATE [Blocks] SET [School_ID] = (SELECT
[Voronoi].[School_ID] FROM [Voronoi] WHERE
Contains(Centroid([Blocks].[Geometry]),[Voronoi].[Geometry]));

UPDATE [Population Centres] SET [School_ID] = (SELECT
[Voronoi].[School_ID] FROM [Voronoi] WHERE
Contains([Population Centres].[Geometry],[Voronoi].[Geometry]);
```

Once the spatial assignment was complete the final step in the allocation procedure was to aggregate the socio-economic context indicator values from the city blocks and population centres to the school locations to which the features were assigned. The 1993 census from the INEI contains an indicator of the total individual homes within each city block and population centre which was used to weight the indicator values proportionally based on their size relative to the other socio-economic features. In order to calculate these values the total number of individual homes associated with each school was determined using SQL queries to sum the total count of homes for the city blocks and population centres. These queries were expressed as:

```
SELECT Sum([Blocks].[Homes]) AS [Total Homes] FROM [Blocks],
[Schools] INNER JOIN ON ([Blocks].[School_ID] =
[Schools].[School_ID]) GROUP BY [Schools].[Schools_ID];

SELECT Sum([Population Centres].[Homes]) AS [Total Homes]
FROM [Population Centres], [Schools] INNER JOIN ON
([Population Centres].[School_ID] = [Schools].[School_ID]) GROUP
BY [Schools].[Schools_ID];
```

Once the total homes associated with each school had been determined, the individual indicator values from the socio-economic features were weighted and summed to produce a single value for the indicator for each school. The query to weight and aggregate these values multiplies the indicator value for each socio-economic feature by the total number of homes in that feature and then divides the value by the total number of homes associated with the school. This query was expressed as:

```
SELECT Sum([Indicator].[Value]*[Blocks].[Homes]/[Schools].[Total
Homes]) FROM [Indicator], [Blocks], [Schools] INNER JOIN ON
([School_ID]) GROUP BY [Schools].[Schools_ID];
```

This process produced socio-economic indicators aggregated at the school level that were included in the analysis along with the indicators measuring the other four components of the education system, namely inputs, processes, outputs, and outcomes.

The calculation and allocation processes revealed that six of the 41 sampled schools did not have sufficient socio-economic indicators to be included in the analysis. Although removing these schools from the analysis reduces its representativeness of the population of schools in the study area, the socio-economic data associated with these schools contained too many null values to warrant their inclusion. With the geographic catchment associated with each remaining school and the indicators aggregated to the school level based on these catchments it was possible to develop an index of education quality, with indicators representing all five components of the education model, to predict absenteeism at non-sampled schools. These methods are fully described in the following sections.

6.1.2 Calculating an Education Quality Index

Development of an index for the quantification of education quality was required in order to compare education quality between schools within the study area. However, as discussed previously, the definition of what comprises a quality education is dependent on the perspective of the particular stakeholder who is evaluating the education system and/or individual schools within the system. To this point education quality has been broadly described and defined in this thesis using the five component model of the education system in Figure 2.4. However, a quantitative index of quality at the school level requires not only indicators describing the five components, but also a theoretical basis for the determination of the relevance of the indicators chosen relative to the perspective of a particular stakeholder in the education system.

One method that has been implemented for the evaluation of education quality using multiple individual indicators is target-based weighted averages (TBWA) (Hall & Bowerman, 1995, Peters, 2002, Leahy, 2005). This method is responsive to the perspectives of different stakeholders in that it allows individuals and/or groups to determine which aspects of education are most relevant to their definition of education quality. Using TBWA stakeholders determine which indicators will be included in the analysis, as well as the optimal (target) values and the boundary values (minimum and maximum) for each included indicator. Lastly, the stakeholder can determine which indicators are more or less important to the overall evaluation by assigning relative weights to each indicator included in the analysis. This approach to the evaluation of education quality can be employed by education planners and decision-makers at all levels of an education system to develop norms against which all schools within their jurisdiction can be evaluated and compared from year to year.

Characterising each of the selected indicators by specifying the minimum and maximum acceptable bounds of the indicator as well as a target value that determines whether the indicator is a cost (where the target tends toward the minimum bound), a benefit (where the target tends toward the maximum bound), or neutral (where a mid-range value that falls between the bounds) (Peters, 2002). Defining indicators as either cost, benefit or neutral in the TBWA method standardises the values of each indicator to a common range. This is important, as the indicators in the s-EMIS measure different aspects of the education system using different metrics. For example, some indicators are expressed as percentages, some as ratios, and others represent raw count data. Standardising the values of each indicator allows indicators using different scales to be combined into a single index, where each indicator is measured in the zero to one range [0 …1] based on their relative distance from a specified target value representing an evaluator's optimal value within the defined bounds of the indicator. TBWA assigns values that fall outside the specified boundaries of an indicator a value of zero. In all cases, values at the target receive an optimal score of one. This evaluation method enables stakeholders not only to define their preferences by prioritising/weighing each criterion, but also to represent their perspectives by defining how each indicator should be judged relative to all other indicators included in the analysis.

The formulae to calculate the values of the indicator for cost, benefit and neutral indicators where the values are not at either boundary or at the target are shown in equations 6-1, 6-2 and 6-3 respectively.

$$\mathrm{Q_{Cost}} = \left(\frac{\mathrm{Bound_{Max}} - \mathrm{Value_i}}{\mathrm{Bound_{Max}} - \mathrm{Value_T}}\right) \tag{6-1}$$

$$Q_{Benefit} = \left(\frac{Value_i - Bound_{Min}}{Value_T - Bound_{Min}}\right) \tag{6-2}$$

$$Q_{Neutral} = \left(\frac{Value_i - Bound_{Max}}{Value_T - Bound_{Min}}\right) where\ Value_i < Value_T$$

$$Q_{Neutral} = \left(\frac{Bound_{Max} - Value_i}{Bound_{Max} - Value_T}\right) where\ Value_i > Value_T \tag{6-3}$$

Where:
Q is the standardised indicator value,
$\mathrm{Value_i}$ is the indicator value,
$\mathrm{Value_T}$ is the target value for the indicator,
$\mathrm{Bound_{Min}}$ is the minimum boundary for the indicator, and

$Bound_{Max}$ is the maximum boundary for the indicator.

In this thesis, as discussed previously in Chapter 3, absenteeism is evaluated from the perspective of an education planner and decision-maker at the local and/or regional administrative levels within the Peruvian education system (i.e., at the UGELs and DREs). Clearly, an education planner is likely to take a different perspective in his/her evaluation of education quality than would other stakeholders such as teachers, parents and school administrators. Education planners and decision-makers are likely to have different opinions on which aspects of the education system are more important, considering that they must take into consideration not only the quality of education provided to students, but also the efficiency and effectiveness of how that education is delivered.

A policy planner evaluating inputs into education is likely to be concerned with satisfying the broad needs of students and also improving the efficiency of education delivery. In this case, an education policy planner may set target values based on accepted education system policy and resource constraints. For example, the ratio of students to teachers might be considered optimal at 15. However, the realities of the education system (i.e., resource constraints) may be such that 20 is a more appropriate target. Clearly, for this indicator, higher ratios are undesirable as they signify teachers that must work with large numbers of students at a time, while values much lower than 20 may indicate that teachers are being underutilised. For this indicator, and for all indicators, the education policy planner can derive the minimum and maximum boundary values from either the observed minimum and maximum values in the study area, or from national or regional policy standards. Another important input indicator, the length of the school year, is also important to the policy planner, as they would clearly like to ensure a common number of school days, to the degree possible, for all schools within the system.

A policy planner would also be particularly concerned with process-based indicators. The desertion rate is a particularly important process indicator for policy planners because it describes how effectively students are being educated at the school. The rationale is that a high desertion rate will occur, especially in rural and remote areas, when families cannot justify the time and money required to educate their children, or when they are unable see the value of their children's participation in the education system. In addition, the indicator of students who are of the appropriate age is important as it shows the overall ability of the education system to educate, promote, and graduate students successfully in a timely manner and prepare them for the next level of schooling and other future opportunities.

In terms of context, an administrator is most likely to be concerned with home-based factors that directly affect the students' ability to perform and benefit from instruction while at school. These includes the ability of the parent to aid the student in their studies, which can be indirectly measured by the level of parent literacy, the education level they have attained, and the spoken-language of the adult population in the school's surrounding neighbourhood. Also, conditions within homes that affect a students' capacity to learn such as access to electricity (for lights and computers) are clearly important. Youth employment would also be of concern to a policy planner, as employment takes away school and/or home time that would be spent studying and preparing for school. Finally, average wealth, nutrition and sanitation are also relatively important to the policy planner since they describe the overall condition of the student's home environment which impacts directly on their ability to benefit fully from instruction. The average wealth indicator used in this thesis, shown in equation 6-4, is derived from a calculation of multiple census-based indicators gathered by the INEI, and has been shown to be statistically valid in prior research (Leahy, 2005).

$$\text{Wealth} = \frac{\begin{pmatrix} (1-[\text{POR with poor wall construction material}]\times 2)+ \\ (1-[\text{POR with poor ceiling construction material}]\times 2)+ \\ (1-[\text{POR with poor floor construction material}]\times 2)+ \\ ([\text{POR with a radio}]\times 1)+ \\ ([\text{POR with a B\&}W\ Telveision]\times 1)+ \\ ([\text{POR with a Colour Telveision}]\times 1)+ \\ ([\text{POR with a stereo}]\times 1)+ \\ ([\text{POR with a VCR}]\times 1)+ \\ ([\text{POR with a washing machine}]\times 2)+ \\ ([\text{POR with a refrigerator}]\times 2)+ \\ ([\text{POR with a vacuum cleaner}]\times 1)+ \\ ([\text{POR with a floor polisher}]\times 1)+ \\ ([\text{POR with a sewing machine}]\times 1)+ \\ ([\text{POR with a weaving machine}]\times 1)+ \\ ([\text{POR with a computer}]\times 1.5)+ \\ ([\text{POR with a telephone}]\times 1.5)+ \\ ([\text{POR with a private automoblie}]\times 3)+ \\ ([\text{POR with a work automobile}]\times 3)+ \\ ([\text{POR with a work van or truck}]\times 3)+ \\ ([\text{POR with a motorcycle}]\times 2)+ \\ ([\text{POR with a bicycle}]\times 1)+ \\ ([\text{POR with a work tricycle}]\times 1) \end{pmatrix}}{35} \times 100 \qquad \textit{6-4}$$

$where\ POR = "Proportion\ of\ Residences"$

Outcomes and outputs are also important to the policy planner as they reflect directly the successes and failures of the education system in preparing students for future opportunities. However, given the poor quality of the source data in Peru only one outcome indicator (adult literacy), and zero output indicators could be included in the education quality index. The central problem with the indicators for these two components of the education model was, again, a large number of null values in the database. Null values can be used in a database to indicate cases of 'not applicable', 'no data' or 'zero' for a particular observation. However they may also be the result of unreported data, and thus represent errors in the database. In the absence of proper documentation, it must be assumed that the null values are the result of schools not reporting data or that data were not transferred into the MINEDU and INEI database, which is clearly problematic in a general sense for the analysis of education data in Peru.

While a small number of null values may not be overly problematic with respect to the education quality index, indicators which contain a majority of null values clearly cannot be used for a reasonable assessment of education quality. In addition to the reasons noted above, null values may occur because data are missing at random (MAR) or missing not at random (MNAR), which is the case for the majority of the indicators in the s-EMIS developed in this thesis. MNAR refers to the case where data for a particular group, cohort or segment of the study area have a significantly lower reporting rate than all other groups, cohorts or segments. This is the case for the rural schools and population centres in the study area which chronically under-report data to the MINEDU and the INEI respectively. In cases where an indicator contains a majority of null values MNAR, inclusion of the indicator will lead to clear bias in the output, and thus the indicator must be rejected from the analysis. In the case of nulls which are MAR it is appropriate to substitute the null value with either zero or a neutral value (e.g., the regional average for the reported values of the indicator).

The education quality index developed in this thesis is listed in Appendix B. The table lists the indictors which are included in the index by which component of the education model they represent as well as their TBWA boundary, target and weight values. Null values, which were encountered only in the process indicators from the MINEDU data, were substituted with the regional average as shown in the table. The index produces an education quality value for each school in the study area in the theoretical range of 0 to 56, where 56 represents the highest possible level of education quality as measured by the index. The actual observed values measured for all schools in the study area ranged from 15.26 to 37.12, suggesting that the highest performing schools only score 66.3% of the theoretical maximum. While this may have immediate policy implications for education planners these generally low education quality scores are more likely the result of the depressed socio-economic condition of the study area. In total socio-economic indicators account for 41, or 73.2%, of the theoretical maximum score of 56, which suggests that the home situation of the students contributes significantly to the lowering of education quality within the study area.

In addition, as can be seen in Figure 6.5, there is a disparity between rural and urban education quality as measured by the index. Rural schools average 32.41 on the education quality index, as compared to 33.75 for urban schools. A Student's t-test of the difference between means shows with 95% confidence that this difference is not a function of random chance. This raises clear policy implications for the policy planner to address the disparity between urban and rural education quality, and also opens the door to the use of spatial analytical methods, as discussed later in this chapter.

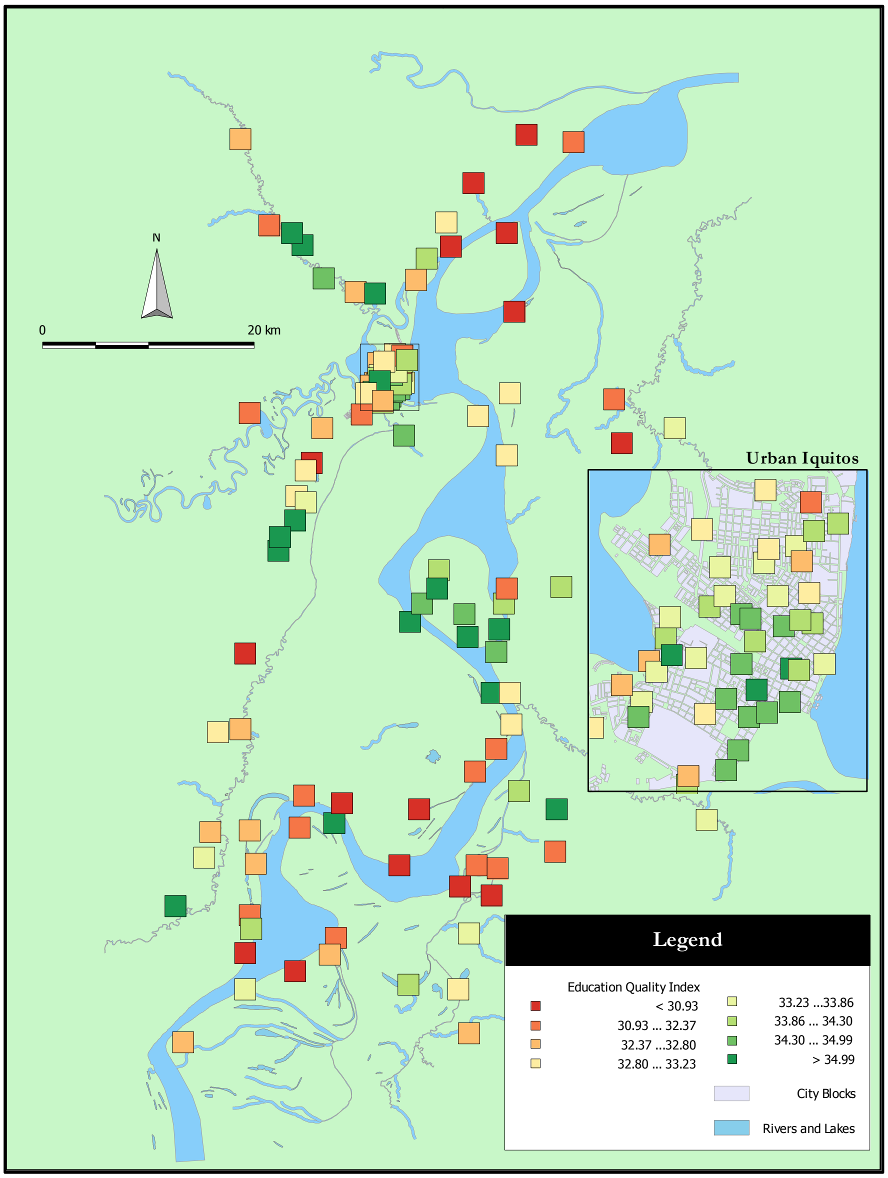


Figure 6.5 – Education quality index

6.1.3 Prediction of Absenteeism at non-Sampled Schools

Prediction of the expected absenteeism at the non-sampled schools is required in order to compare the quality of education, as measured on the index developed in the previous section, against absenteeism, for all schools in the study area. The predicted values are generated through the estimation of a multiple ordinary least squares (OLS) regression model for sampled schools using the indicators from the s-EMIS. As noted previously, there are a total of 109 available indicators calculated from the data obtained by the MINEDU and the INEI in the s-EMIS used in this thesis. While a model using all 109 indicators would likely be able to explain most, if not all, of the variance in absenteeism at the sampled schools, it is likely that the model would exhibit high multicollinearity, given the close correlations between many of the 109 variables. This violates one of the requirements of the general linear model and renders any estimates of the dependent variable subject to error. Multicollinearity among the 109 indicators was evaluated by calculating Pearson correlation coefficients for all input variables and assessing the statistical significance of the resulting relationships (i.e., the resulting p-values). For example, the distance from the urban centre of Iquitos was found to be highly correlated with sanitation and water connections for homes, as well as the student to teacher ratio, desertion rates, and the percentage of parents who had completed primary, secondary and tertiary levels of education.

Another possible source of error in the prediction of absenteeism is redundancy among the 109 indicators, due not to collinearity, but to the inclusion of multiple indicators which have the same definition (i.e., which measure the same processes or phenomena). For example the number of homes with sanitary connections is represented twice in the 109 indicators, once as the raw count of homes with sanitary connections and once as the percentage of homes with sanitary connections. Clearly, both of these indicators should not be included in the analysis as they measure the same phenomenon using different metrics. Additionally, socio-economic indicators such as those measuring Spanish-language speakers are calculated for all adults who speak Spanish and for children with parents who speak Spanish. While these indicators do not measure exactly the same phenomenon they exhibit high multicollinearity and should not both be included in the regression model. The final source of redundancy in the indicators comes from the enrolment, intake and desertion rates. These rates are included several times, measured as apparent, gross and net rates. Again, while they do not measure the exact same phenomenon (i.e., gross enrolment and apparent enrolment are not the same), they exhibit high multicollinearity and should not all be included in the regression model.

Removing redundant indicators from the full set of 109 indicators left 25 indicators with which to estimate absenteeism. Using Minitab 15 statistical software a forward and backward iterative regression model was estimated for absenteeism on these 25 independent variables. Forward and backward regression adds or removes one variable at each iteration. This process requires a minimum statistical significance with which to reject or accept each variable (in this case the 95% confidence level, p=0.05). The result of this process was a regression equation built on five of the input indicators. Table 6.1 shows the indicators included as well as their coefficients and their statistical significance. The overall model has an adjusted r-squared value of 53.3 and a p-value of 0.001, meaning that 53.3% of the overall variance in absenteeism can be explained by the model with 99.9% confidence that the observed results did not occur by chance.

Education Component	Indicator Description	Coefficient	P-value
Context	Intercept	4.18	0.001
	Percentage of children with parents who speak Spanish (Spanish)	-0.3754	0.034
	Percentage of youth aged 15 and under who work (Work)	0.0958	0.032
	Percentage the youth and adult population (ages 15 and up) who completed primary education (Primary)	0.345	0.021
Process	Average overall age of students enroled in primary school (Age)	3.626	0.027
Input	Apparent intake rate for grade one females (Intake)	0.01991	0.002

Table 6.1 – Regression coefficients for absenteeism prediction

A plot of the residuals, shown in Figure 6.6, shows little deviation from the observed values of the dependent variable. This is confirmed by a histogram plot shown in Figure 6.7, which approximates a normal distribution with slight negative skew. Further evidence of the statistical validity of the model is shown in the Pearson correlation matrix in Table 6.2 which indicates a lack of association between the independent variables. Thus, the variables in the model are orthogonal.

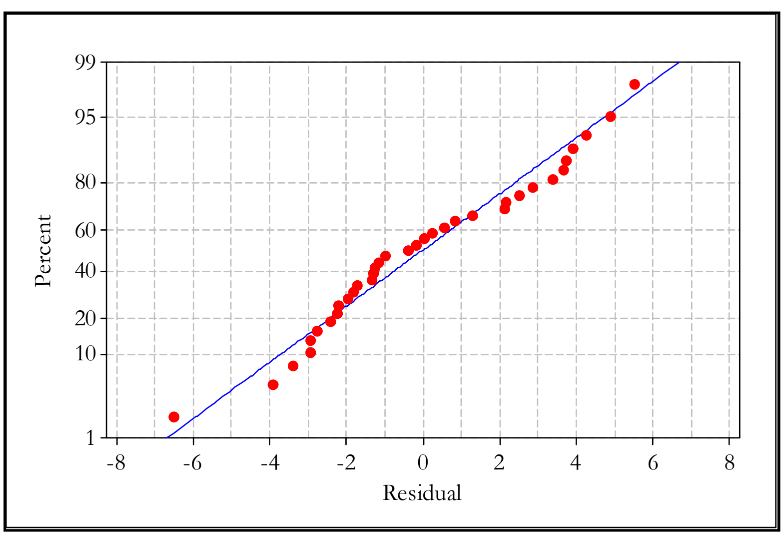


Figure 6.6 – Plot of residuals from the prediction model

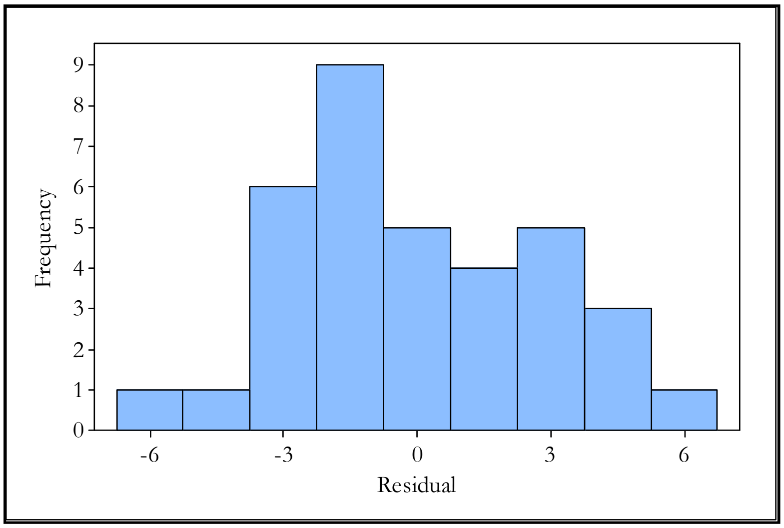


Figure 6.7 – Histogram of residuals from the prediction model

Indicators	Spanish	Work	Primary	Age	Intake
Spanish	1				
Labour	0.108 0.532	1			
Primary	0.136 0.437	0.218 0.209	1		
Age	0.175 0.315	0.268 0.119	0.470 0.004	1	
Intake	0.209 0.228	-0.162 0.354	-0.446 .007	-0.297 0.083	1

Table 6.2 – Pearson correlation matrix

The final output of the model is shown in equation 6-5. The coefficients, when applied to the schools in the study area, predicted overall absenteeism in the range of 0.343 to 28.41 days per student at the non-sampled schools. This range corresponds well to the observed absenteeism at the sampled schools (which fall in the range from 1.98 to 18.79 days per student).

$$\begin{aligned}\text{Absenteeism} = 4.18 - 0.3754(\text{Spanish}) + 0.0958(\text{Work}) + 0.01991(\text{Intake}) \\ + 0.345(\text{Primary}) + 3.626(\text{Age})\end{aligned} \qquad \textit{6-5}$$

A map of the overall days per student absenteeism for all schools in the study area, both sampled and predicted, is shown in Figure 6.8. The figure shows a clear distinction between days per student urban and rural absenteeism, which corresponds to the urban and rural disparity shown in the map of education quality as measured by the index. A discussion of these trends, as well as an analysis of the sample data, follows in the next sections of this chapter.

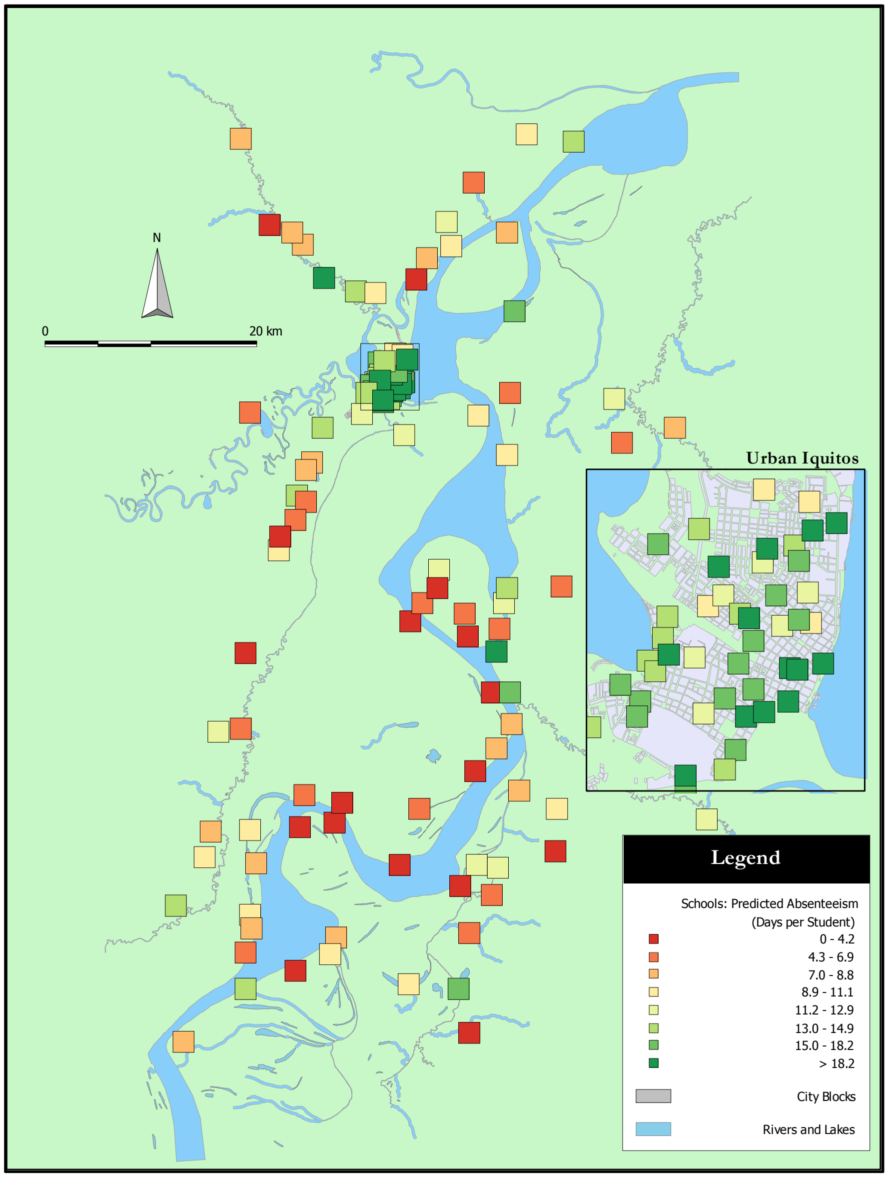


Figure 6.8 – Predicted absenteeism

6.2 Analysis Results and Discussion

The remainder of this chapter discusses the results of a series of analyses, both statistical and spatial, on the effect of absenteeism on education quality. Several objectives underlie these analyses. The first is to identify whether the evaluated education quality at schools in the study area is significantly related to absenteeism and, if so, to determine the causes and reasons for this relationship. The second objective is to learn whether absenteeism and/or education quality within the study area exhibits observable spatial patterns. The third objective is to establish whether or not the relationship between education quality and absenteeism is spatially dependant. Prior to performing spatial analyses on the data, basic non-spatial statistical analyses are used to provide a more general summary of absenteeism and its distribution among the population of students and schools in the study area.

6.2.1 Preliminary Analysis of the Absenteeism Data

Statistical analysis of the absenteeism sample data at the student level was accomplished using Student's t-test and analysis of variance (ANOVA). These methods were used to test whether the means between two or more independent groups of data are unequal relative to the null hypothesis of no difference in group means. The t-test calculates the ratio of the difference between sample means divided by the standard error of the difference. In the case of male and female absenteeism $t_{cal}=1.051$ and $p=0.293$ with $df=5544$. Hence, the null hypothesis of no difference between male and female absenteeism cannot be rejected with at least 95% confidence. However, this test was conducted on all sampled students by gender and thus the lack of difference does not preclude the existence of gender-based disparities in absenteeism relative to the influences of grade, age and/or the other internal characteristics of the data.

ANOVA tests were used for instances where there were more than two independent groups within the data. ANOVA can be either one-way (groups based by one characteristic of the data) or n-way (groups based on two or more characteristics of the data). The one-way ANOVA procedure produces an F statistic that analyses the difference between means for a dependent variable, in this case absenteeism, by an additional independent variable, such as student grade. This analysis tests the hypothesis that several means are unequal relative to the null hypothesis of no difference. In addition to determining whether or not significant differences exist among the means, ANOVA includes both *a priori* contrasts and *post hoc* tests which can be used to determine which means differ significantly.

An ANOVA of absenteeism by grade produces $F=4.022$ with $p=0.001$ suggesting that there is 99.9% chance that at least one of the grades differs significantly from the others on mean absenteeism (the per-grade mean days of absenteeism are shown in Figure 6.9). *Post hoc* tests reveal that there are two homogeneous groups (i.e., the means of the members of the homogeneous group are not significantly different) of grades that generate the significant F statistic result. The first homogeneous group includes all grades except grade one and the second includes all grades except grade three. Thus, the significant difference between means revealed by the ANOVA is the result of the significant difference between mean absenteeism for grades one and three.

These results are not surprising given that the highest rates of overall absenteeism occur in the first grade, with a declining trend to a minimum at grade three, and subsequent increasing absenteeism to the end of primary school. The slight decrease in mean absenteeism for grade six is not significant, as discussed above, although it does create a trend which appears to be somewhat sinusoidal in shape. The high rates of absenteeism at the beginning of the primary cycle would suggest that students who benefit least from the earliest years of primary education (i.e., those who are not frequently present) do not continue to participate in the education system. The high rates of absenteeism for the end of the primary cycle may also suggest that students who are frequently absent do not continue onto secondary education, which is clearly problematic from the perspective of an education policy planner. However, it is not possible to confirm this as there is no way currently of assessing the outcome of primary education relative to the matriculation of students to secondary school.

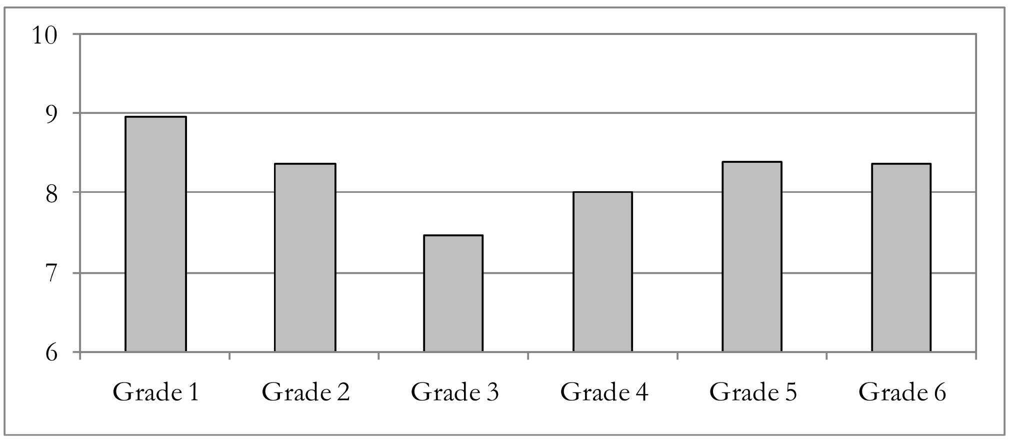


Figure 6.9 – Mean days of absenteeism by grade

As discussed previously, early childhood education is critical to future life opportunities. Hence, the high level of mean days of absenteeism per student in the earliest and latest grades of primary school is clearly of significance to education planners. In order to address this, a more thorough understanding of the processes that lead to absenteeism and of the outcomes of absenteeism is required. Looking at outcome of absenteeism first, it may be likely that high rates manifest in the education system through increased attrition and grade repetition. From the perspective of an education planner attrition and grade repetition are problematic as they reduce the efficiency of the education system and result in increased costs and resource requirements. Thus, an understanding of the contribution of absenteeism to these problems can help reveal to some extent the effect of absenteeism on education quality.

The extent to which absenteeism contributes to attrition can be determined by looking at the difference in mean days of absenteeism between students who completed the sampled school year versus those who did not. Overall, students who did not complete the school year averaged 16.18 days of absenteeism per student against 8.17 days of absenteeism per student for those students who did complete the school year. A t-test produced a t_{cal}=8.536 with p=0.000 and df=5544. Hence, the difference in mean days of absenteeism between students who did and did not complete the school year is significant beyond the 99.9% confidence level and the null hypothesis of no difference can be rejected. Note that this analysis does not take into account students who completed the school year but were not promoted to the next grade, as student performance data were not available from the MINEDU. In all cases students who did not drop out of school are considered to have been promoted to the next grade. Furthermore, as discussed previously, this assumption is not unrealistic given the propensity of education systems in developing countries to promote students regardless of individual performance.

Disaggregated by grade, as shown in Figure 6.10, the mean days of absenteeism for students who completed the school year follows the same sinusoidal shape as Figure 6.9. The trend for those students who did not complete the school year, however, resembles a U shape, with the exception of the high mean value for grade four. The high average value for grade four (38.40 days) is the combined result of a single student who recorded 88 days of absenteeism prior to dropping out of school and a small sample size. These trends suggest that while mean days of absenteeism do increase as students advance through the final years of primary school, the increase is largely due to the effect of student attrition, as shown by the slight drop in mean days of absenteeism for students who did complete the final grade of primary school.

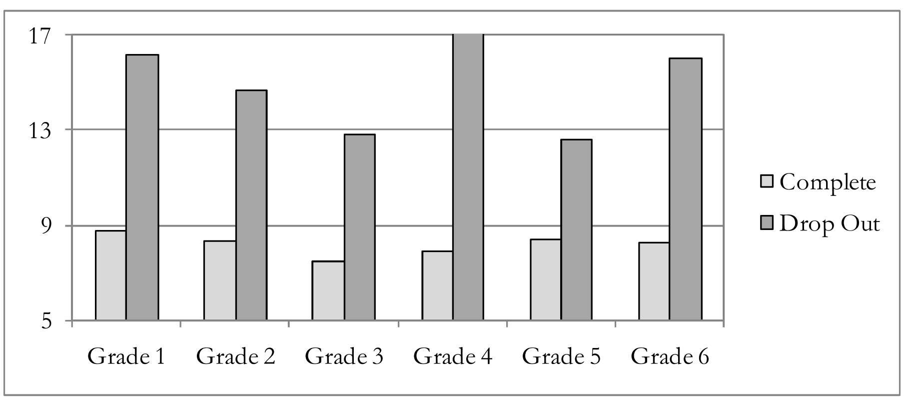


Figure 6.10 – Mean days of absenteeism by grade for students who did not complete the school year

The extent to which absenteeism contributes to grade repetition can be determined by examining the difference of mean days of absenteeism between students of the appropriate age for their enroled grade and students not of the appropriate age for the same grade. Students may be of inappropriate age for their enroled grade as a result of late enrolment or instances of grade repetition. Grade repetition is problematic for education planners as it equates to the need for extra resources to be spent to promote students to the final grade of primary school. It is also problematic for these students as it extends the time required to complete the primary school cycle and thus reduces future opportunities for continued study and promotion onto higher levels of education. Also, as noted previously, grade repetition is a critical factor in the decision of parents to keep their children in school. The appropriate age of students for each grade is based on the Peruvian education system policy of enroling students at age 5 for a primary school cycle of 6 years, as shown in Table 6.3.

Grade	Minimum Age	Maximum Age
1	5	6
2	6	7
3	7	8
4	8	9
5	9	10
6	10	11

Table 6.3 – Appropriate age ranges by grade

Overall, students of the appropriate age averaged 7.58 days of absenteeism against 9.13 days of absenteeism for students of inappropriate age. For these means $t_{cal}=7.532$ with $p=0.000$ for $df=5544$. Hence, the null hypothesis of no difference can be rejected with more than 99.9% confidence. At the per grade level, as shown in Figure 6.11, the same general trends noted with attrition are apparent, with increased overall days of absenteeism per student occurring at the earliest and final grade. The same sinusoidal shape is also apparent for students of appropriate age, as well as the U shape for students of inappropriate age. These trends again suggest that while mean days of absenteeism do increase as students advance through the final years of primary school, the increase is likely somewhat due to the effect of student grade repetition, as evidenced by the slight drop in mean days of absenteeism for students of appropriate age (i.e., students who did not repeat grades) in the final grade of primary school.

Finally, the overall contribution of absenteeism to attrition and grade repetition can be measured by removing all instances of absenteeism incurred by overage students and students who drop out from the sample and performing a t-test on the difference of means for these two independent groups. This test shows that students of the appropriate age who completed the school year averaged 7.55 days of absenteeism per student against 9.15 days of absenteeism per student for students who dropped out and/or are not of the appropriate age for their enroled grade. In this instance $t_{cal}=7.804$ with $p=0.000$ for $df=5544$ degrees of freedom. Hence, the null hypothesis of no difference in mean days of absenteeism between students of appropriate age who completed the school year and other students can be rejected beyond the 99.9% confidence level. At the per grade level, the same trends are again apparent, as shown in Figure 6.12.

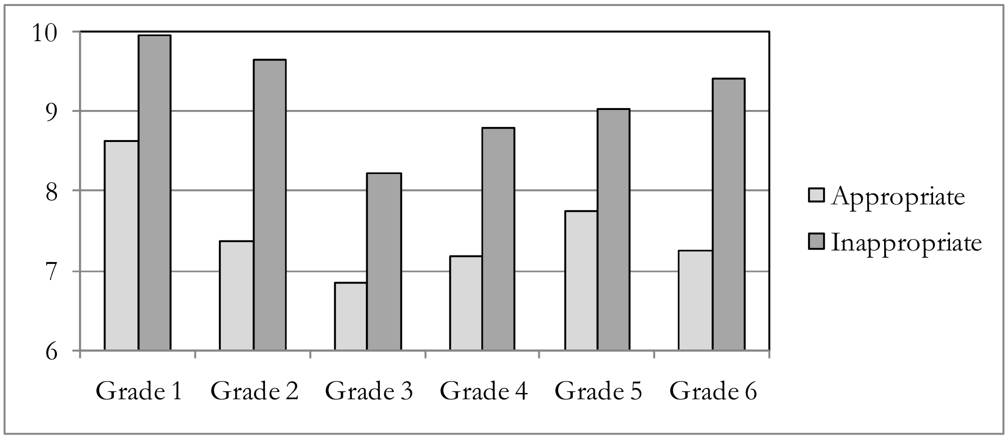


Figure 6.11 – Mean days of absenteeism by grade for students of inappropriate age

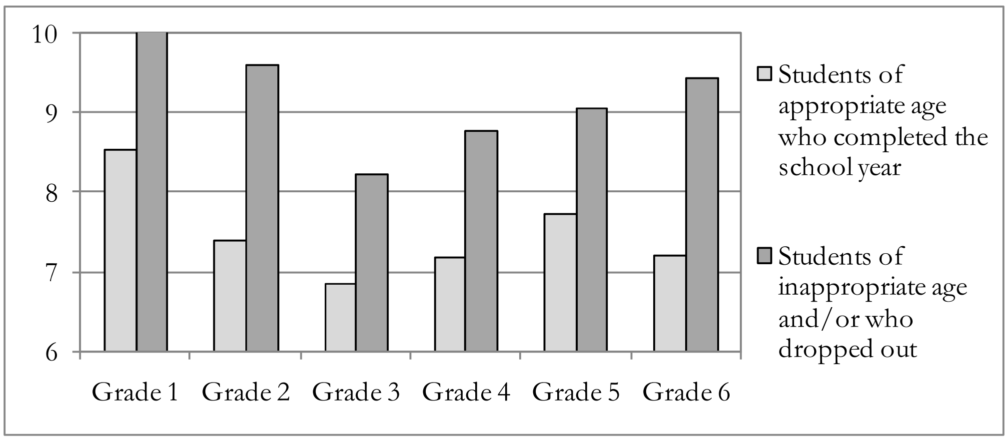


Figure 6.12 – Mean days of absenteeism between student groups

It is clear from these analyses that absenteeism has an association with both attrition and grade repetition. However, the results cannot tell whether absenteeism is the cause or the result of the observed trends. From the perspective of an education planner the analysis is worth pursuing as attrition and grade repetition are endemic in the study area, as shown in Table 6.4. Policy designed to improve the quality of education should focus on the minimisation of absenteeism to reduce the high rates of attrition and grade repetition. In particular, the high rate of attrition in the earliest two grades of primary school should be of concern for education policy planners as they may indicate that students and/or parents do not value the education provided and thus do not participate in the education system.

Hence, it is clear that absenteeism does affect education quality, as shown both by the statistical tests of the relationship between these two variables and by the elevated rates of attrition and grade repetition experienced by frequently absent students. While these are important observations, they cannot tell an education policy planner very much about the actual reasons for absenteeism and how to implement policies intended to reduce this. Education policy planners need to understand the underlying processes that lead to absenteeism and as such they need to understand the reasons for absenteeism before they can improve the education system.

Grade	% of Students of Inappropriate Age	% of Students who Dropped Out
1	25.596	2.902
2	44.136	1.279
3	44.918	0.546
4	51.078	0.431
5	50.300	0.840
6	51.706	1.034

Table 6.4 – Over-age student and attrition rates

These underlying reasons can be assessed by examining the reasons for absenteeism collected during the teacher interviews. As discussed previously, student health is considered to be a major contributor to absenteeism in general and in the study area in particular. However, a t-test shows that on average health-related absenteeism results in significantly fewer days of days of absenteeism per student than non-health related absenteeism, at 3.39 and 6.72 days per student respectively. Specifically, t_{cal}=-21.024 with p=0.000 for df=7446. Hence, the null hypothesis of no difference between health-related and non-health related absenteeism can be rejected with more than 99.9% confidence. While this suggests that socio-economic reasons for absenteeism are of most concern, the aggregation by category masks some important trends in the mean days of absenteeism for the individual reasons for absenteeism, as shown in Table 6.5.

Category	Reason	Percentage of Total Absenteeism	Mean Days of Absenteeism	Standard Deviation
Health-related	Infectious Disease	3.41	7.44	4.508
	Corporeal	1.45	2.86	3.071
	Cerebral	5.50	2.03	1.545
	Other	13.95	3.00	3.856
Non-health related	Work	7.00	2.83	4.490
	Economic	26.67	3.31	3.075
	Environmental	12.47	2.35	2.225
	Social	29.55	4.45	4.995

Table 6.5 – Mean days of absenteeism by reason

The table shows that infectious diseases result in the highest average number of days of absenteeism, which is of particular concern in the study area given the equatorial Amazonian conditions. From a policy standpoint there is a clear need to mitigate instances of infectious disease among the primary school population, as these may result in outbreaks of illness as well as prolonged absences from school. In addition, the high standard deviation for this reason for absenteeism may indicate that the length of absence is extended by the severity of the disease and conversely that in many cases students may return to school before they are completely recovered. As noted previously, returning to school in a state of diminished health is not optimal for the student. The table also shows that economic and social reasons make up over half of the total days lost to absenteeism for the study area and thus these are two critical reasons which should be addressed by education policy reform.

Further analysis of the sample data using an n-way ANOVA can be used to examine the effect of multiple inherent characteristics of the sample data on absenteeism. An n-way ANOVA divides the sample data into groups by gender, grade and reason for absenteeism and tests the null hypotheses that there is no significant difference in days of absenteeism by reason, grade and gender. This method investigates interactions between groups as well as the effects of individual characteristics on mean days of absenteeism. The result outputs a matrix of sample means, as shown in Table 6.6, in which each cell contains the mean days of absenteeism by gender for each combination of student grade and reason for absenteeism.

Reason	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
Infectious Disease	9.86 8.72	6.56 6.88	5.13 6.50	6.19 7.42	7.00 6.32	9.33 9.73
Corporeal	2.23 2.97	2.91 3.00	5.06 2.40	2.90 2.48	2.43 2.09	2.67 2.80
Cerebral	1.95 1.91	2.33 2.09	1.91 2.09	2.19 1.96	2.00 1.86	2.02 1.87
Other	2.89 2.47	3.63 3.06	3.22 2.98	2.41 2.95	3.30 2.93	3.24 2.99
Work	2.60 2.99	3.25 2.61	2.20 2.16	2.24 3.84	2.96 2.60	2.81 3.28
Economic	3.78 3.82	3.60 3.53	3.17 3.07	2.90 3.14	3.13 3.10	3.25 3.16
Environmental	2.93 2.51	2.40 2.03	2.11 1.97	2.20 2.27	2.42 2.72	2.23 2.46
Social	4.76 5.21	4.90 5.05	4.03 4.12	4.32 3.96	4.98 4.24	4.31 3.96

Table 6.6 – Mean days of absenteeism by gender, reason and grade

The statistical significance of these results, shown in Table 6.7, reveals that mean days of absenteeism are significantly affected by grade and reason, but not by gender. In addition, interactions between these groups are generally not significant. Differences of means by grade and gender, reason and gender, and by grade, reason and gender are all not statistically significant. Differences in means by grade and reason are the only between group interaction that produces a statistically significant result.

These results, which are shown in histogram form by grade and reason in Figure 6.13, show in general that the trend for each reason follows different patterns. The absenteeism trends for infectious disease, economic, environmental, labour, and social reasons all follow generally the sinusoidal trend noted previously. The trend is most pronounced for absenteeism due to infectious disease, and notably does not show a drop in the final primary grade noted in the previous grade-based absenteeism figures in this analysis. The absenteeism trends for reasons such as corporeal, and other, on the other hand appear to be a reversal of the sinusoidal trend. The spike in absenteeism due to corporeal reasons for grade three students is of particular interest as is the reversed trend by grade displayed for this reason in general. The final reasons, absenteeism for cerebral reasons shows no appreciable trend and appears to be largely steady across all grades.

Source	Degrees of Freedom	F-statistic	p-value
Grade	5	3.770	.002
Reason	7	129.845	.000
Gender	1	.242	.623
Grade * Reason	35	2.216	.000
Grade * Gender	5	.820	.535
Reason * Gender	7	.590	.765
Grade * Reason * Gender	35	.935	.578

Table 6.7 – Statistical significance of difference of means for mean days of absenteeism

As noted previously, many of the indicators in the data available from the MINEDU and the INEI are inherently collinear. The most persistent of these relationships is the high association between the indicators and the Euclidean distance (in kilometres) from schools to the geometric centroid of the urban centre of Iquitos. Due to this high collinearity, the distance from Iquitos was not used either in the education quality model or in the predictive model for absenteeism at the non-sampled schools. However, this collinearity clearly demonstrates that different processes occur at the schools within the study area based on their relative location with respect to Iquitos.

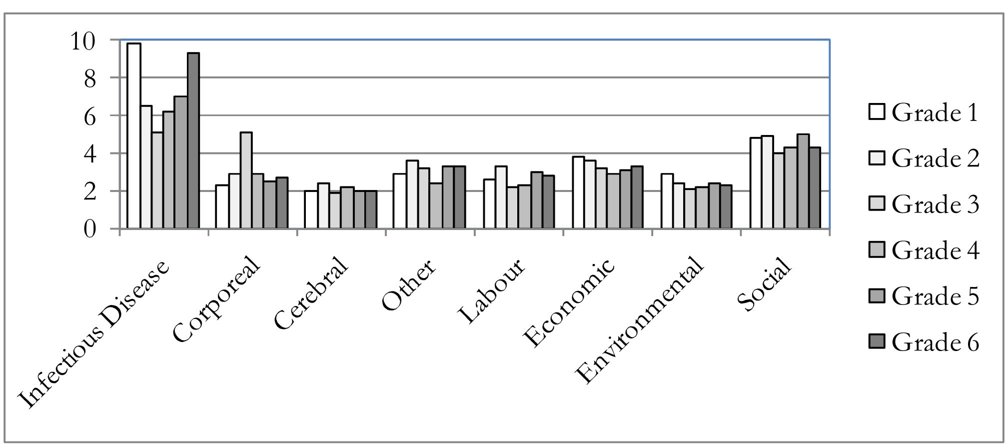


Figure 6.13 – Means days of absenteeism by grade and reason

For example, in the previous sections of this chapter a map of education quality and a map of predicted absenteeism showed similar (yet inverse) trends, namely decreasing education quality and increasing absenteeism with increasing distance from the urban centre of Iquitos. This suggests that there is likely to be a negative association between absenteeism and education quality at the school level, mediated by the effect of distance from Iquitos. The strength and validity of this relationship can be tested using a bivariate Pearson correlation. The results of this test confirm that absenteeism and education quality are significantly negatively correlated ($r=-0.377$, $p<.001$). Hence, an education policy planner seeking to improve education quality in the study area requires an understanding of the dynamics of rural and urban contexts in terms of their influences on absenteeism.

In relation to this reality, while not strictly a spatial analysis, the sample data can be split into urban and rural sub-samples and a t-test can be performed on the sub-sample data to determine if there are statistically significant differences between observed absenteeism based on school location. The mean absenteeism at the urban and rural schools is 7.12 and 14.12 days per student respectively. The value of $t_{cal}=-26.905$ with $p=0.000$ for $df=5544$ allows the null hypothesis of no difference in mean days of absenteeism between urban and rural schools to be rejected beyond the 99.9% confidence level. Figure 6.14 plots the mean days of absenteeism at each of the schools in the study area versus the distance from Iquitos, which clearly shows that rural schools consistently experience elevated average rates of absenteeism relative to their urban counterparts.

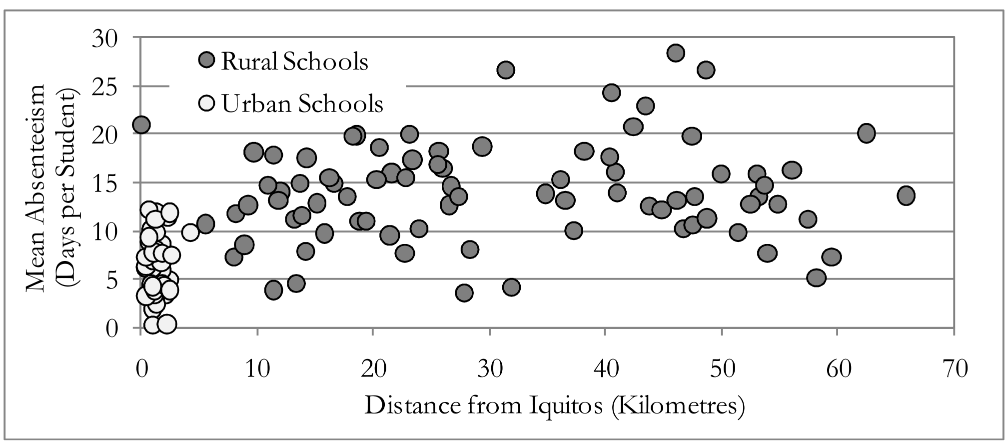


Figure 6.14 – Mean days of absenteeism by school location

If there are clear differences in the reasons for the different rates of absenteeism between rural and urban areas there may be a need for separate policies to address the realities of the two contexts. The analysis and discussion above identified that attrition and grade repetition contribute significantly to absenteeism. Thus, disaggregating the sample data further to determine the percentage of students who repeat and drop out of school from urban and rural areas, as shown in Table 6.8, is critical to understanding the disparity between urban and rural absenteeism.

Location	Attrition Rate	Inappropriate Age Rate
Urban	0.302%	40.362%
Rural	5.727%	65.308%

Table 6.8 – Rate of attrition and over-age students in primary school

The difference in means between the attrition rates and the rate of students of inappropriate age for the urban and rural portions of the study area are statistically significant beyond the 95% confidence level. Thus, the patterns of increased attrition and grade repetition in the rural portion of the study area, which correspond to significantly increased absenteeism in the rural areas, needs to be addressed in order for education planners to understand the underlying processes. The disparity in absenteeism rates can be more thoroughly addressed using the spatial analytical methods described in Chapter 5. These methods and the results of their application to the sampled and non-sampled schools are discussed in the following section.

6.2.2 Analysis of Cluster and Spatial Autocorrelation Results

This section examines the spatial patterns inherent in the absenteeism data, measured at the school level. A test for complete spatial randomness (CSR) is required first to ensure that spatial autocorrelation and other analyses of spatial patterns can be performed on the point data. In this thesis the empirical distribution function (EDF) is used to evaluate the presence of CSR for the point data, i.e., for the distribution and location of the schools in the study area. Using the formulae described previously in equations 5-4 and 5-5 the expected average and variance in the point data is computed. From these values, calculated as 8098.96 and 23583.01 respectively, a Z-score for the dataset can be obtained from equation 5-6. This Z-score provides an indication of either the presence or absence of CSR for the points in the dataset.

A significantly large Z-score for a given dataset suggests a valid rejection of CSR for the distribution of schools in the study area. A positive and significant score implies a regular, dispersed spatial pattern, while a negative and significant score implies a spatially clustered point distribution. The Z-score of -0.266 calculated for the points representing the schools in the study area in this case is statistically significant, which confirms that the points cluster and are thus do not exhibit CSR. A plot of the EDF, with the percentage of the maximum distance on the horizontal versus the percentage of total points on the vertical axis, shown in Figure 6.15, confirms this pattern.

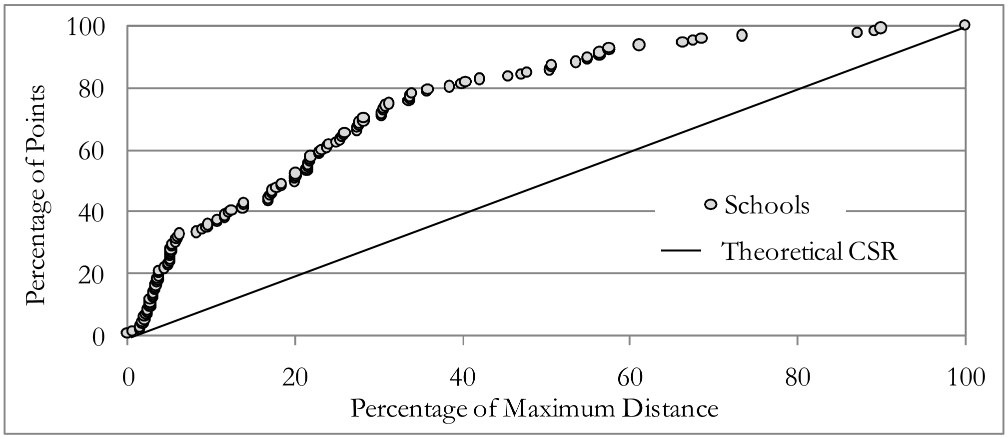


Figure 6.15 – EDF plot of CSR

Once the presence of CSR has been rejected, the spatial dependency of a given variable, in this case absenteeism, can be assessed using both global and local spatial statistics. For example, the tendency for similar or dissimilar values of absenteeism to be spatially autocorrelated with neighbouring points can be evaluated using the global Moran's I statistic, while the global Getis-Ord G statistic can be used to measure whether higher or lower values tend to cluster. A discussion of the local variants of these statistics follows this global level analysis.

At the global level, the Moran's I statistic measures spatial autocorrelation (feature similarity) based not only on feature locations or attribute values alone but on both feature locations and feature values simultaneously. Moran's I returns a value in the range [-1 … 1], where a value near the upper bound indicates concentrations of similar attribute values and a value near the lower bound indicates dispersion. By contrast, the global Getis-Ord G statistic measures concentrations of high and/or low values for an entire study area. A calculated G value higher than the expected G value indicates that high values of the measured variable tend to be concentrated, while a lower than expected G value suggests low values of the variable tend to be concentrated.

Both the Moran's I and the Getis-Ord G statistics were calculated using ESRI's ArcGIS software package. As discussed previously, the software requires several input settings before the computation can be performed. For both the I and the G statistics the zone of indifference method for conceptualising spatial relationships was used. This method uses a fixed kernel that places the emphasis on neighbouring schools within a critical threshold distance. Once that critical distance is exceeded, the level of impact of neighbouring schools quickly drops off. This conceptualisation best fits both the urban (co-located) and rural (dispersed) school point patterns, where neighbouring urban schools are more likely to have an impact on each other than are the highly dispersed rural schools. Contiguity was calculated based on a three kilometre critical limit, using Euclidean distances.

Moran's I returned a global statistic of 0.764220 with an expected statistic of -0.007874 and a Z-score of 16.896774. This suggests that there is less than 1% chance that the observed spatial autocorrelation of absenteeism at the schools could be the result of random chance. The global Getis-Ord G returned a global statistic of 0.00241, with an expected statistic of 0.00076, a variance of 0.00 and a Z-score of -5.23672. This suggests, again, that there is less than 1% chance that the values in the dataset are concentrated purely by chance. It also suggests that there is a slight tendency for schools with low rates of absenteeism to be concentrated, or schools that are characterised by good attendance records tend to be located nearby each other whereas schools with high rates of absenteeism are more spatially dispersed relative to each other. These statistics suggest that there are spatial dependencies in absenteeism at the schools in the study area that cannot be attributed purely to chance. Local autocorrelation and cluster analyses allow these trends to be explored further by mapping results for each school within the data set.

The local Moran's I_i statistic returns two values for each point in the dataset, namely an index value, and a Z-score. A high positive Z-score at a point indicates that the surrounding features have similar values. Multiple adjacent features having similarly high Z-scores demarcate a cluster of schools with similarly high or low values. A low negative Z-score for a feature indicates the feature is surrounded by dissimilar values, i.e., a feature with a negative Z-score is more likely to have a different rate of absenteeism relative to its neighbours. The local Moran's I_i Z-scores in Figure 6.16 show two clusters of schools which exhibit spatial autocorrelation on the absenteeism variable, one urban (occupying most of urban Iquitos) and one rural in the south-central portion of the study area. In the map legend the Z-scores are assigned to discrete ranges based on the significance levels of the Z-scores using the standard normal distribution to give a better indication of the statistical validity of the spatial autocorrelation detected by Moran's I_i at each school.

The local Getis-Ord G_i is able to test if the spatial autocorrelation identified by the I_i statistics are in fact significant clusters of high or low values. The G_i returns a Z-score for each school, however in this case a significantly high Z-score for a point indicates its neighbours have similarly high absenteeism values, and vice versa. The higher (or lower) the Z-score the stronger the spatial autocorrelation between the point under consideration and its neighbours based on the rate of absenteeism at each school. A Z-score near zero on the other hand indicates no autocorrelation of similar absenteeism values, and thus the school under consideration has a rate of absenteeism dissimilar to its neighbours. The Getis-Ord G_i results in Figure 6.17 verify that low rates of absenteeism are clustered in urban Iquitos, while high rates of absenteeism are clustered in the rural portion of the study area. In addition, the G_i results suggest that the urban cluster extends just beyond the boundary of the urban limits to include peri-urban schools on or just beyond the boundary of the city blocks.

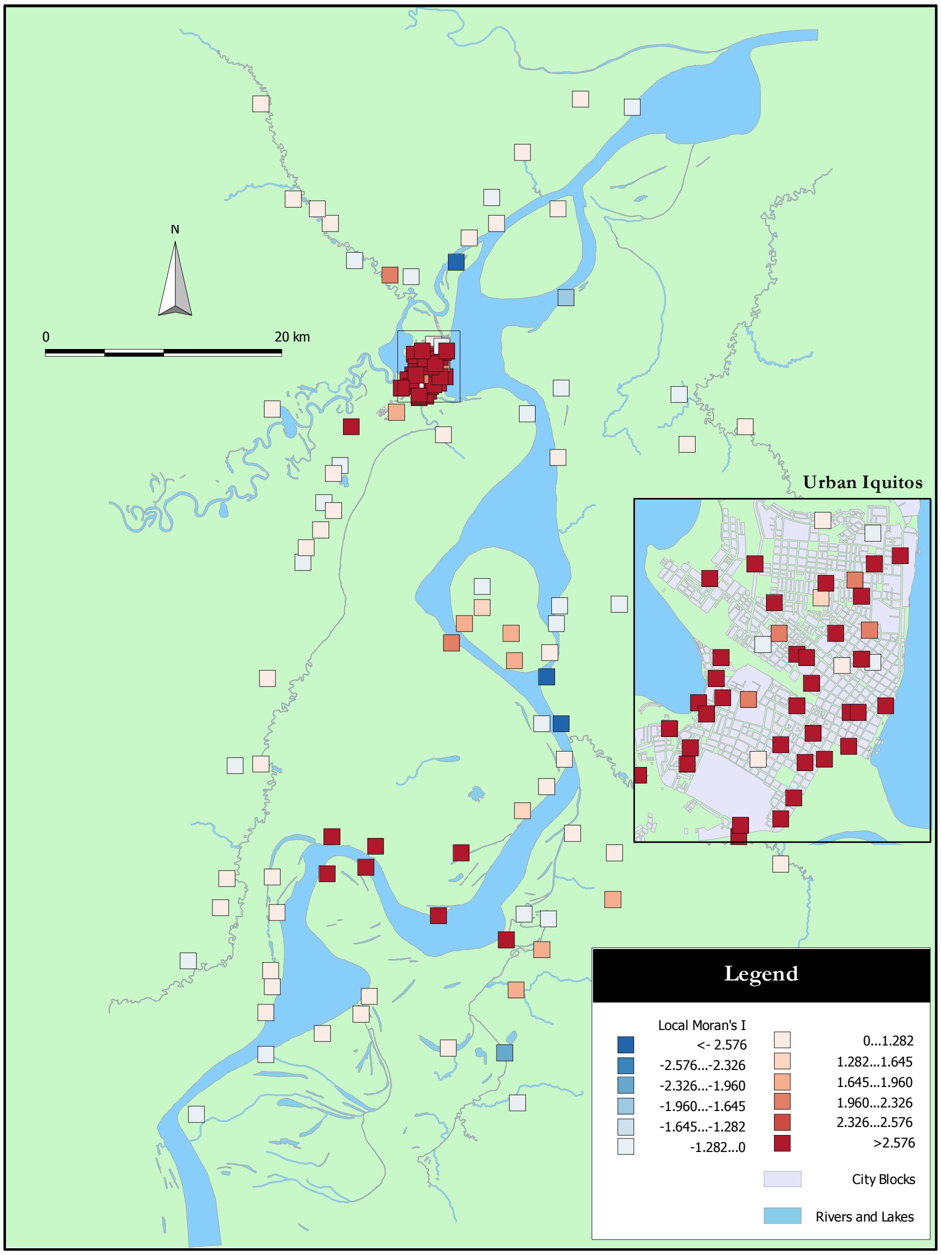


Figure 6.16 – Local Moran's I_i results for absenteeism

Global and local tests for spatial autocorrelation can also be performed on the education quality index values calculated for each school to detect the presence of spatial autocorrelation on this variable. Moran's I returned a global statistic of 0.153514 for education quality with an expected statistic of -

0.007874 and a Z-score of 5.410821. This suggests that there is less than a 1% chance that the observed clustering of education quality at the schools could be the result of random chance.

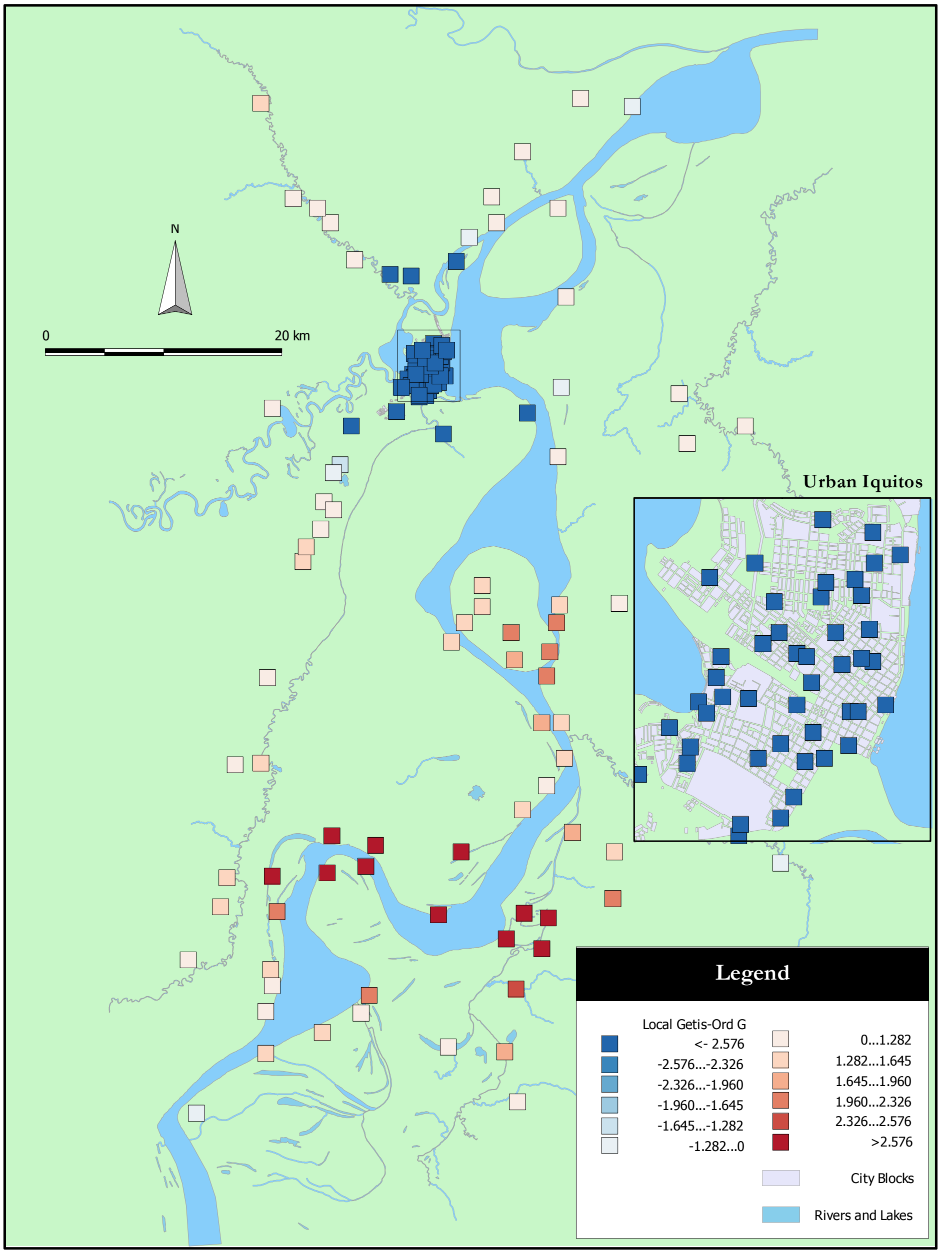


Figure 6.17 – Local Getis-Ord G_i results for absenteeism

The global Getis-Ord G returned a global statistic of 0.000110, with an expected statistic of 0.000104, a variance of 0.00 and a Z-score of 3.064872. This suggests again that there is less than a 1% chance that the spatial autocorrelation of the education quality values at the schools would be observed purely by chance. It also suggests that there is a slight tendency for clustering among the high values of education quality. Thus, there are observable spatial dependencies in education quality at the schools in the study area that cannot be attributed purely to chance.

The local Moran's I_i for education quality, shown in Figure 6.18, shows that the overall significance of the spatial autocorrelation for this variable is not as significant as it was for absenteeism. However, it is important to note that the clusters that are identified by this test are co-located with the clusters indicated in the I_i test for absenteeism suggesting spatial dependencies in the absenteeism and education quality variables (which will be explored further in the next section). The urban cluster of schools with similar education quality values is much smaller than the absenteeism cluster, however, and its centroid is located near the southern boundary of urban Iquitos. The rural cluster for education quality also contains fewer schools than the rural cluster for absenteeism, and significantly identified one school (notable as the only red point in the map) which has a very significantly dissimilar (in this case much higher) education quality index value than its neighbours.

The local G_i, shown in Figure 6.19, verifies that the rural cluster describes low education quality (except one school which has a relatively high education quality value). This may indicate to planners (given that these schools are also a cluster of high absenteeism values) that absenteeism is playing a significant role in lowering the education quality at these schools (the reasons for elevated absenteeism at these schools is explored further in the next section). In the urban portion however, G_i detects only a very low significance of spatial autocorrelation for higher values of education quality, suggesting that there is little spatial dependency in education quality between the schools in the urban portion of the study area. This suggests that the relatively low rate of absenteeism at the urban schools does not significantly affect the quality of education (again, this is discussed further in the next section).

The analysis results and discussion presented in this section have shown that there are observable spatial patterns in the distribution of both absenteeism and education quality. There is a clear trend toward rural clustering for both the absenteeism and the education quality variables, and urban clustering on the education quality variable. There also appears to be spatial dependencies between these variables noted by the co-location of the clusters for the urban and rural areas.

This suggests that different underlying processes are occurring at urban versus rural schools with respect to education quality and absenteeism and also suggests that education planners require a fuller understanding of these processes in order to improve the quality of education being delivered in the study area through planned intervention that is sensitive to both the urban and rural contexts. Thus the next section uses GWR to examine first the underlying causes and contributory factors to absenteeism at the school level and is followed by an analysis of the spatial dependencies between absenteeism and education quality.

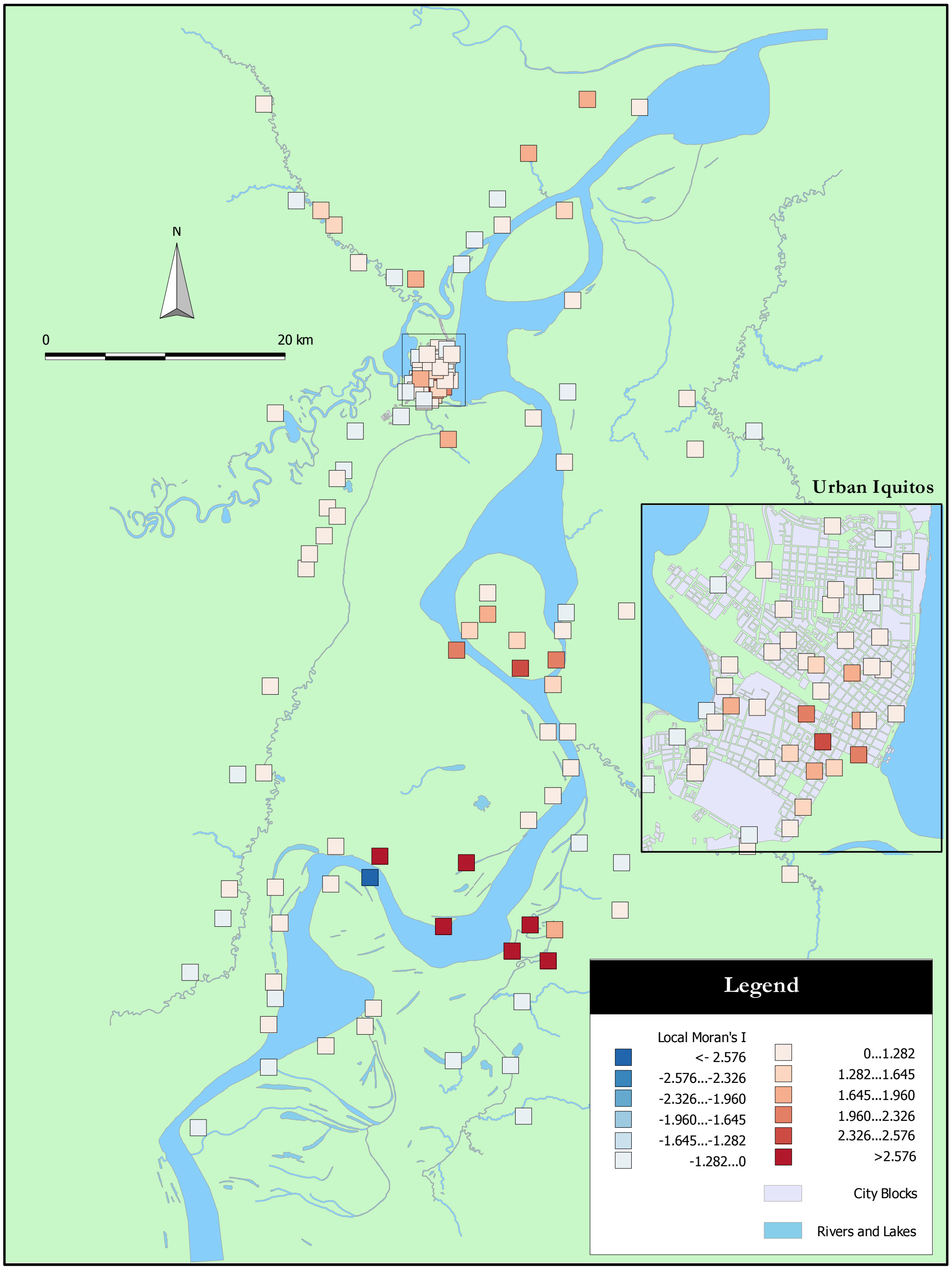


Figure 6.18 – Local Moran's I_i results for education quality

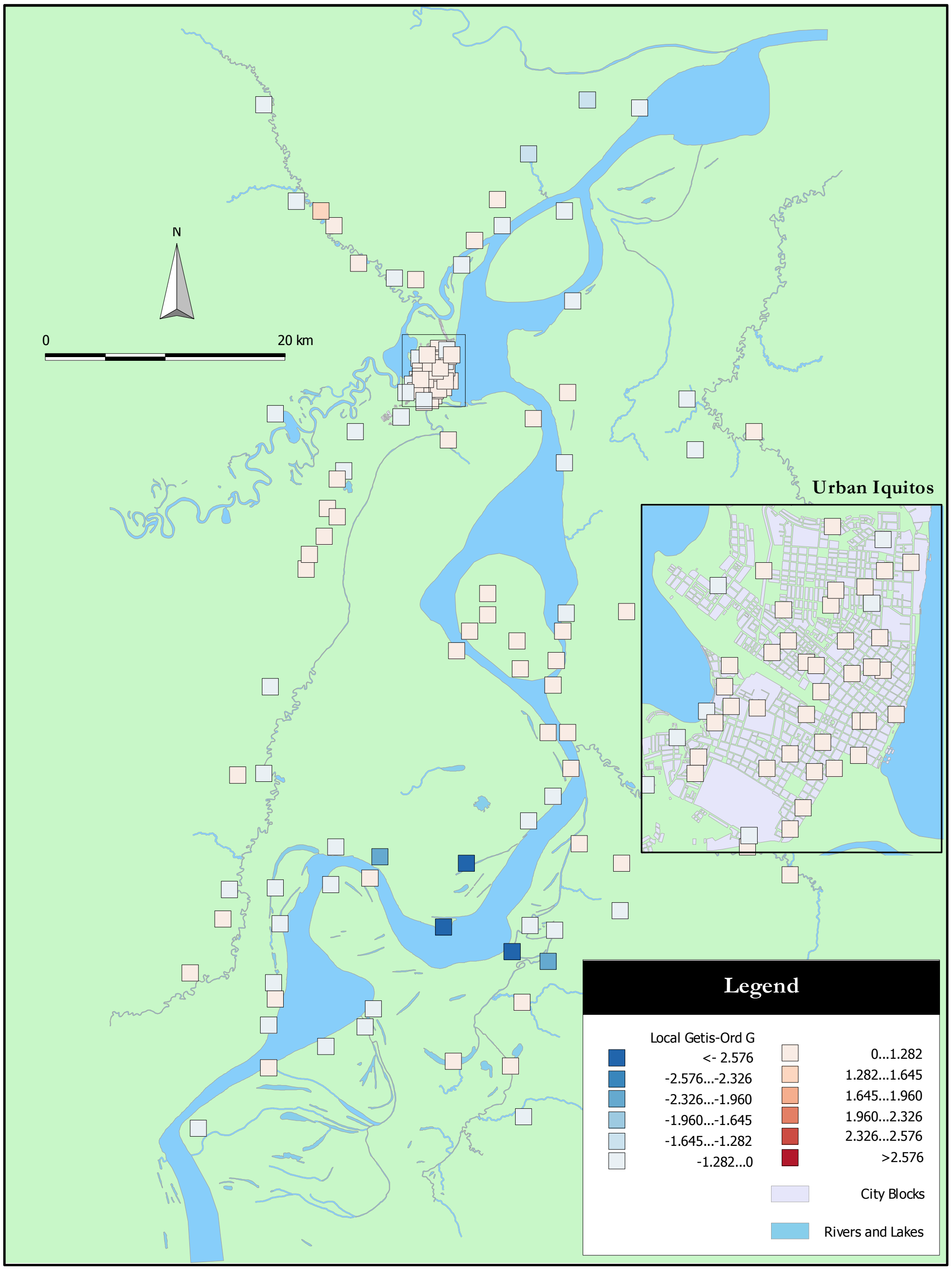


Figure 6.19 – Local Getis-Ord G_i results for education quality

6.2.3 Geographically Weighted Regression

The analyses presented in the previous section, while useful for identifying spatial autocorrelation among schools on the absenteeism and education quality variables (calculated using the TBWA method listed in

Appendix B), lack the ability to explain effectively the local level effects that produce these spatial dependencies. This final analysis focuses on the use of GWR to determine the spatial variability underlying the variables that contribute to absenteeism at the school level as well as measuring the spatial dependencies of absenteeism on education quality. The analysis was conducted with the GWR 3.0.1 software package (Fotheringham et al., 2002) using Gaussian spatial weighting with an adaptive kernel. An adaptive kernel (a sampling window that varies its bandwidth to include a minimum number of observations) is appropriate where observations may be sparse across a study area (such as the widely dispersed rural school locations) and ensures that a sufficient number of neighbouring points are included in the regression calculations for each observation (Fotheringham et al., 2002).

The output from the GWR software is a set of summary results, which include the standard OLS regression calculations and diagnostics, diagnostics for the overall GWR results to allow comparison with the OLS regression output, and local regression parameter estimates and diagnostics for each independent variable in the model at each school. These statistics and diagnostics can be output either as tables or as vector-based geographic file formats that can be imported into standard GIS packages. As discussed previously, the goal of GWR is to improve the fit of an OLS regression model by accounting for the effect of non-stationarity in the spatial patterns and dependencies of the independent variables on the dependent variable at the school level within the model. In general, the level of improvement in the ability to estimate the dependant variable (absenteeism in this case) in a GWR analysis can be evaluated by comparing the coefficient of determination (R^2) from the GWR results with the R^2 from the OLS regression results using the same set of independent variables.

Thus, a GWR of absenteeism is compared against the OLS regression model developed for prediction of absenteeism using the independent variables listed earlier. As reported previously, the OLS model returned an adjusted R^2 value of 0.533 and a p-value of 0.001, which indicate that 53.3% of the overall variance in absenteeism was explained by the independent variables with 99.9% confidence that the observed results did not occur by chance. The results from the GWR calculated for the study area shows an improvement in the adjusted R^2 value (R^2=0.829). This improvement can be statistically verified by examining the ANOVA results included in the GWR output in which the OLS regression model is compared with the GWR model.

The results of the ANOVA indicate that the GWR model is a significant improvement on the OLS model (F=3.6812, p=0.001), and thus the null hypothesis of no difference can be rejected. In addition, the GWR is able to reduce the Akaike information criterion (AIC) from 611.09 to 603.08. The AIC is a measure of the goodness of fit of an estimated statistical model and is an operational way of trading off the complexity of an estimated model against how well the model fits the data (Akaike, 1974). Reductions in the AIC value correspond to models that better fit the data. Thus, the GWR model can be considered a somewhat better fit of the independent variables to the absenteeism variable at the global level on this criterion.

Global regression parameters returned by the GWR, as shown in Table 6.9, demonstrate that absenteeism is negatively associated with the percentage of children with parents who speak Spanish. Thus, the rate of absenteeism is decreased at all schools, according to the global parameter estimate, by an increase in the percentage of children who have Spanish-speaking parents. The other four independent variables are all positively associated with absenteeism, thus increases in the values of these variables (such as an increase in the percentage of youth aged 15 and under who work) are accompanied by increases in the rate of absenteeism. Note also that the intercept has a positive value, which may indicate that there is a background rate of absenteeism, on the order of 2.63 days of absenteeism that can be expected at each school in the study area.

Education Component	Indicator Description	Coefficient	T-value	p-value
Context	Intercept	2.6304	0.5681	0.090
	Percentage of children with parents who speak Spanish (Spanish)	-0.4762	-10.7925	0.150
	Percentage of youth aged 15 and under who work (Work)	0.0558	2.8601	0.160
	Percentage the youth and adult population (ages 15 and up) who completed primary education (Primary)	0.1417	8.3550	0.090
Process	Average overall age of students enroled in primary school (Age)	0.0006	0.0514	0.130
Input	Apparent intake rate for grade one females (Intake)	4.7574	13.3135	0.050

Table 6.9 – Estimated global GWR parameters for absenteeism

Since the R^2 comparisons confirm the GWR model is statistically significant, the parameter estimates at each school within the dataset can be evaluated in order to gain useful insight into the spatial variability of the relationships between each of the independent variables and the dependent absenteeism variable. As with the local Moran's I_i and Getis-Ord G_i, the most effective way to evaluate the parameter estimates is to view them in map form and visually assess any spatial patterns. One way of achieving this is to use consistency mapping. The goal of consistency mapping is to view changes in these parameter values from school to school within the study area and thus assess their consistency (or lack thereof) through space (Leahy, 2005). A consistency map of the local parameter estimates of the five independent variables in the OLS regression and GWR models can thus reveal spatial patterns in the contribution of these variables to the rate of absenteeism at each school, as shown in Figure 6.20.

Shades of successively darker green indicate that the parameter estimate at the school is a negative value which means that the independent variable contributes to a reduction in the rate of absenteeism at that particular school (e.g., there is a negative correlation between the independent variable and the rate of absenteeism). The opposite is true for successively darker shades of red which indicate that the independent variable contributes to an increase in the rate of absenteeism at the school. For example, the Spanish indicator reduces the rate of absenteeism at all schools, however the reduction is large in the rural portion of the study area and in the southernmost section of Iquitos, and is small or medium for the other urban schools. Of interest, the southernmost portion of Iquitos, known as Belen, has consistently been the poorest and most under-privileged area of the city, and thus it is not surprising that it shares some characteristics in common with the rural context.

This result suggests that Spanish-speaking parents (given that the language of schooling in the study area is Spanish) are able to contribute more to their children's education. Thus, it can be assumed that the higher rate of Spanish-speaking parents in the urban versus the rural context (99.4% and 97.7% respectively) contributes to this larger decrease in the urban rate of absenteeism (*Ministerio de Educación*, 2004). A t-test of the difference in means between the rural versus urban schools confirms this assumption with t_{cal}=-1.69 with p=0.038 and df=89. Hence, the difference is significant beyond the 95% confidence level and the null hypothesis of no difference can be rejected. Education planners can thus expect adult literacy programs aimed at the non-Spanish speaking population of the rural portion of the study area to also contribute to lower rates of absenteeism which will have a beneficial impact on education quality overall.

The indicators Work and Primary contribute to an increase in the rate of absenteeism at all schools within the study area. Notably the Work indicator seems to have a smaller effect on the rate of absenteeism relative to the Primary indicator in the urban context, while the relationship is opposite in the rural context. One exception to this general pattern is found for the small number of rural schools north and east of Iquitos which follow the urban pattern for these two indicators. Youth labour is also significantly more prevalent in the rural area, where 7.5% of youth work compared to 2.9% of urban youth who work (*Ministerio de Educación*, 2004). A t-test of the difference in means between the rural versus urban schools confirms that there is a significant difference in rural versus urban youth labour with t_{cal}=1.66 with p=0.000 and df=89. Hence, the difference is significant beyond the 99.9% confidence level and the null hypothesis of no difference can be rejected.

Given that youth labour is more prevalent in the rural context and that it has a larger effect on the rate of absenteeism at rural schools education planners should look at planned interventions in which timing of the school year or the length and distribution of school days are more sensitive to the extra-curricular needs of the students in these areas. In addition, these results suggest that educational attainment of the parents (and thus most likely attitudes towards education) has a large impact on attendance of the children at the urban schools, especially in Belen, where the percentage of parents who have completed primary school is lowest (*Ministerio de Educación*, 2004).

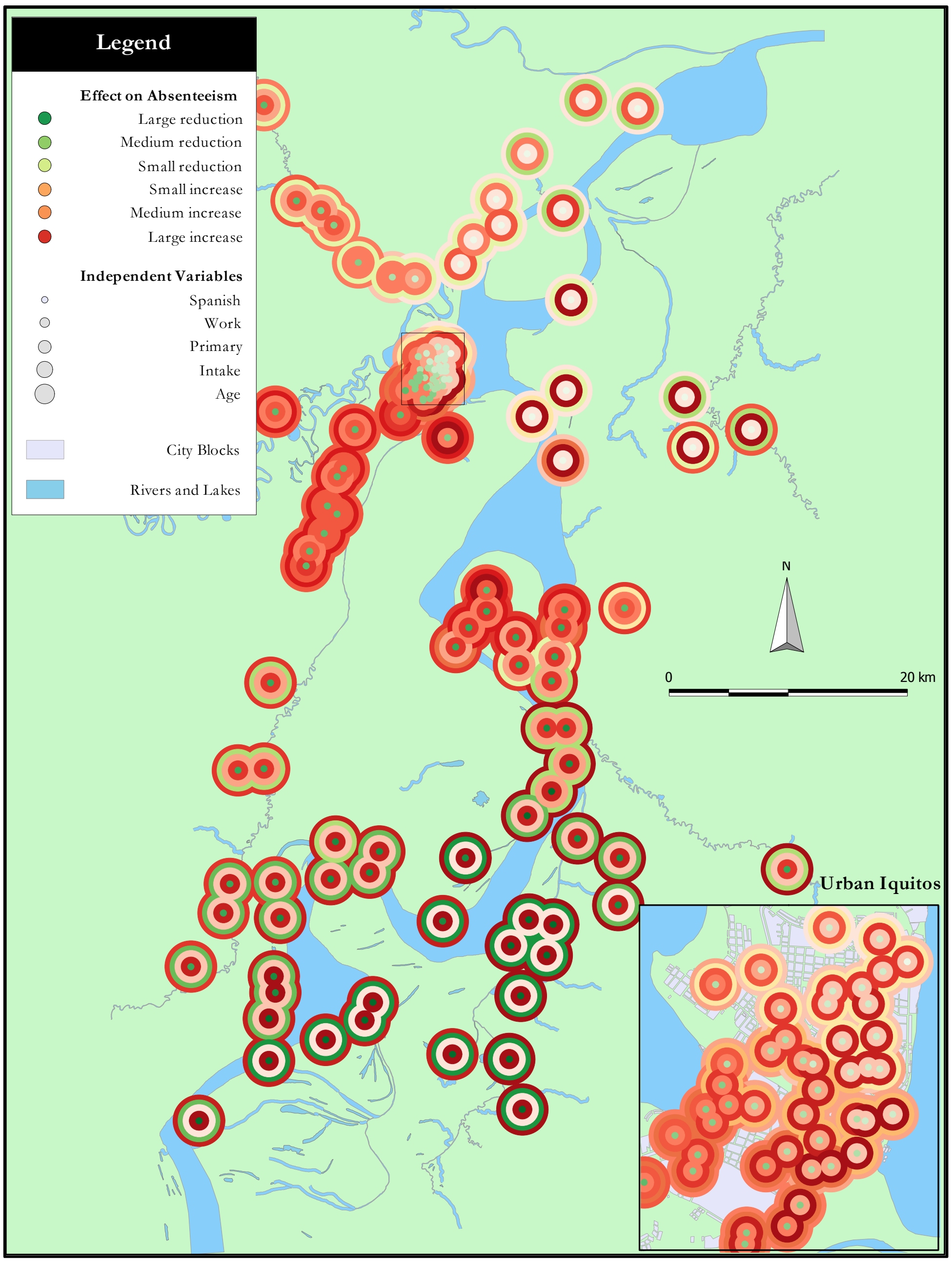


Figure 6.20 – Consistency map of regression parameters on absenteeism

The Intake variable generally contributes to a large or medium reduction of the rate of absenteeism at the rural schools, and generally increases the rate of absenteeism for urban schools. This effect is likely due to that fact that urban schools have larger populations which subsequently means larger yearly intake rates which result in a larger student population which may contribute to overall absenteeism at the school. Thus while this indicator is clearly variable over space these results suggest that the intake rate at the rural schools is not a significant factor in the absenteeism experienced at these schools. The variable Age, however, does contribute to a large increase in the rate of absenteeism at rural schools, suggesting that the over-age students who make up a larger proportion of the student population at these schools (as discussed previously) are significant contributors to the rate of absenteeism at these schools. This is clearly confirmed by the consistency mapping for the Age indicator which shows a medium to high effect on the rate of absenteeism at the rural schools and only a low to medium effect at the urban schools.

The consistency map also shows that the five indicators contribute to large increases in the rate of absenteeism at the peri-urban schools southwest of the urban boundary of Iquitos, as well as for a small group of schools located on a large island south of Iquitos. These schools do not form part of either cluster identified in the previous I_i and G_i discussion. This pattern suggests, however, that these schools may have similar characteristics that have a similar effect on the rate of absenteeism. Finally, for the urban schools the consistency map shows a general decrease in the effect of the indicators (whether to increase or decrease the rate of absenteeism) with increased distance from Belen. It is tempting to suggest that this pattern may be produced by significant differences in the wealth index or the nutrition levels of students between Belen and the rest of Iquitos. T-tests (wealth: t_{cal}=1.29, p=0.105, df=42; health: t_{cal}=-0.886, p=-.190, df=42) confirm with 90% confidence that there is no significant difference in the wealth index of households or nutrition levels of students between these two urban contexts and thus the null hypothesis cannot be rejected.

Thus, the GWR and consistency mapping have clarified the role of the different contributions to absenteeism from each of the independent variables that were identified by the OLS regression model and have noted that these contributions are highly variable over space, especially with respect to the urban and rural contexts of the study area. The GWR has also noted some patterns in the spatial variability which require further study in order to explain. The identification of these patterns gives education planners more understanding of the underlying processes which lead to absenteeism within the study area. However, the main goal of this analysis is to identify clusters of schools where high levels of absenteeism contribute significantly to low education quality (e.g., “hot spots”). Analysis of the characteristic differences between these areas leads to the development of planning policy recommendations for intervention programmes with the goal of reducing absenteeism and thus increasing the overall quality of education throughout the study area. This analysis can be accomplished using GWR with the education quality index value as the dependent variable and absenteeism as the independent variable, as shown in Figure 6.21.

An OLS regression model with absenteeism as the independent variable and education quality as the dependent variable has an adjusted R^2 value of 0.135 meaning that 13.5% of the overall variance in education quality can be explained by absenteeism. An ANOVA of the model produced an F-value of 20.817 with p=0.000 which means there is only a very small chance that the variation in education quality explained by absenteeism would be the result of random chance. The GWR shows an improvement in the R^2 value (R^2=0.528), which suggests that the explanatory power of absenteeism is much stronger when analysed with respect to its spatial variability. This improvement can again be statistically verified by using an ANOVA which indicates that the GWR model is in fact a significant improvement on the OLS model (F=3.6279, p=0.001), and thus the null hypothesis of no difference is rejected. The global parameter estimates returned by the GWR are shown in Table 6.10.

Education Component	Indicator Description	Coefficient	T-value	p-value
	Intercept	34.9033	70.5527	0.000
Process	Mean days of absenteeism	-0.1772	-4.5626	0.000

Table 6.10 – Estimated global GWR parameters for education quality

A visual inspection of the local GWR absenteeism parameters, in Figure 6.21, shows that absenteeism consistently reduces the quality of education, with the exception of a cluster of schools in the middle portion of the study area. It should be noted that the improvement to education quality measured by the GWR for these schools is very small (a maximum increase of 0.1 on a linear index ranging from maximum bounds of 0 – 58 and an observed range of 15.25 – 37.12). In addition, none of these schools which show improved education quality due to absenteeism were sampled, and the slight increase in education quality may thus be a result of errors resulting from the absenteeism prediction model or from the replacement of null values for non-reported indicators from these schools. In any case, these schools should be excluded from the rest of the discussion as the results are confounding and further study (as well as a larger sample of rural schools) is required to determine the exact cause of the slight rise in education quality predicted by the GWR.

In general, the GWR shows that absenteeism has a greater overall effect on rural education quality than it does on urban education quality. This effect is most pronounced for the rural schools in the southern portion of the study area, coincident with and larger in extent than the clusters of similar absenteeism and education values identified previously by the G_i tests. For the urban area the effect of absenteeism is a relatively slight reduction in education quality, again with the largest reductions to education quality occurring in and around Belen.

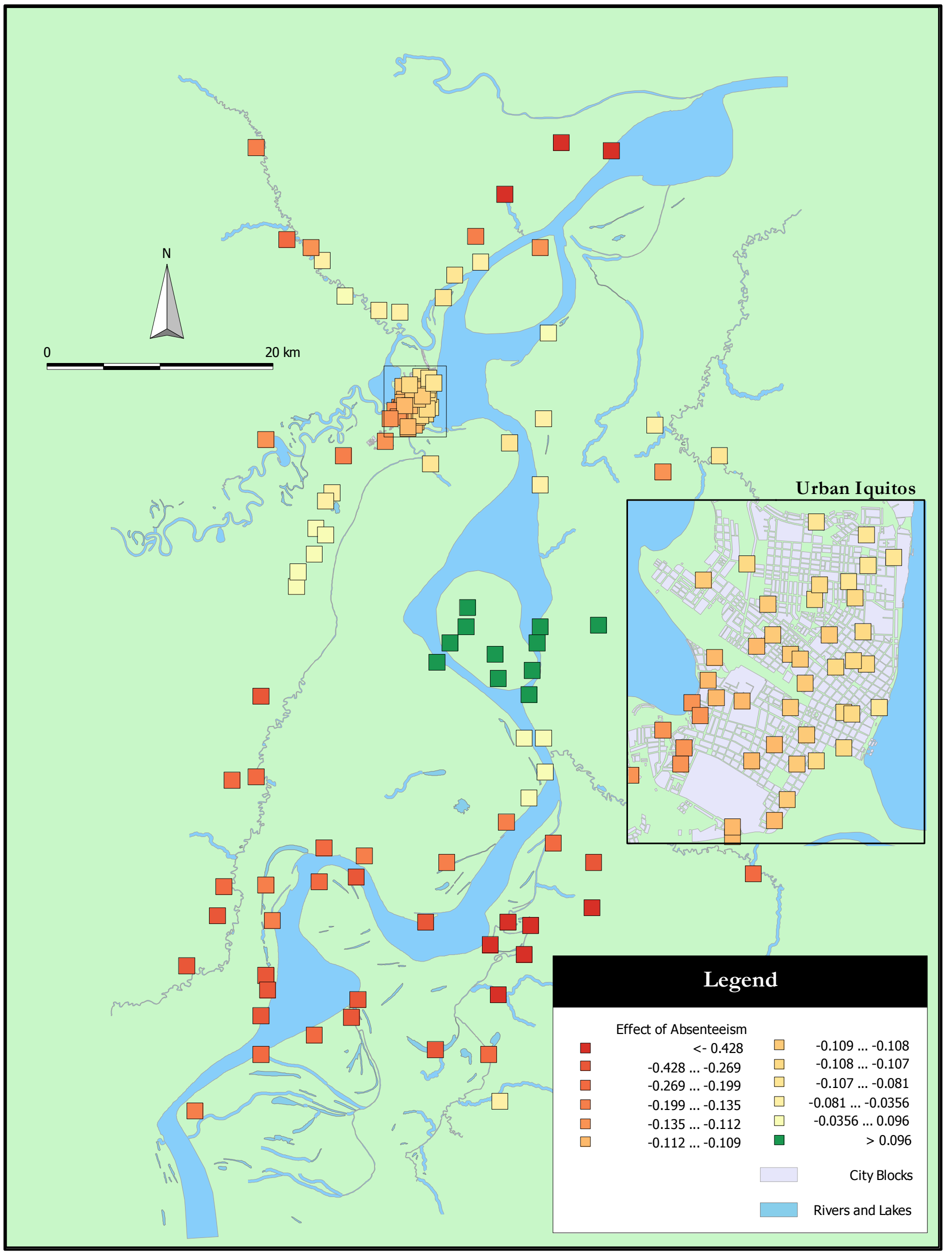


Figure 6.21 – Effect of absenteeism on education quality

Analysing the relationships between education quality and absenteeism using GWR has revealed that the global values observed in the OLS regression parameters are highly variable across space. In addition, each of the variables identified in the absenteeism prediction model also vary spatially, and show clear patterns distributed over urban and rural schools. Consequently, some variables may become more dominant in the local GWR calculations depending on the location of the school within the study area. This trade-off between different explanatory variables is clearly useful to education planners who wish to identify where certain planned interventions may have the most impact (e.g., whether improvement efforts in local areas or individual schools within the study area should focus on youth labour, attrition, and/or grade repetition).

6.3 Summary

The results presented and discussed in this chapter have shown that different methods of analysis at global or local levels provide varying levels of insight that may be of varying interest and relevance to education planners, depending on the nature of the problems under consideration, and the spatial extent of the analyst's or planner's area of interest. While it is often possible to obtain conflicting results from different analyses, the results from the different analyses discussed in this chapter were generally found to corroborate each other. One of the greatest challenges an education planner would face is deciding which analyses should be conducted, depending on the nature and scale of the problems being addressed. As discussed, at national or regional levels, OLS regression may be considered sufficient, with global clustering and Moran's I or basic mapping used for evaluation of any general spatial patterns. However, absenteeism is a local level phenomenon that is clearly heavily influenced by socio-economic and environmental context, and thus education planners working at local levels or developing targeted intervention schemes should be more interested to learn about variability of education quality at local scales, for which the G_i and GWR analyses are perhaps most insightful.

Chapter 7

Conclusion

Since the inception of the EFA movement in 1990, there have been recognisable changes and in many cases improvements to national education systems in developing countries around the world. During the same period reforms have taken place in these countries to strengthen the institutions of democracy including the decentralisation of power and responsibility and the increase of government accountability. These reforms are reflected in changes in the administrative hierarchy and mandate of education ministries such as the MINEDU in Peru which have translated into improved educational experiences for students. These systemic changes have also helped Peru to endure and recover from significant economic and political turmoil to the point that Peru is now relatively politically and economically stable despite the lingering presence of conditions of extreme poverty in many parts of the country.

Globally, examination of the core EFA indicators as well as data collected by the UN, UNICEF and the WB at the national level reveals that, while broad improvements in education quality have been made, many countries have improved only marginally while some have actually worsened. Clearly, the motivation and capacity to achieve the egalitarian ideal of UPC is not uniform throughout the world. In particular, the least developed nations have shown the least progress, while the more developed nations have shown little or no improvement, demonstrating that environmental and socio-economic conditions have a significant and important impact on education and development. The education system in Peru, for example, has shown relative improvement in many of its aspects, particularly with respect to the enrolment and intake rates (e.g., GER and AIR), which suggests that the benefits of early education are being made available to more children than ever before. At a superficial level, this leads to the conclusion that the goals of the EFA movement (specifically, UPC) have been achieved in Peru.

However, the disparities in education quality that exist between nations also exist within nations, and are apparent in both the developed and developing contexts. For example, in Canada, despite equivalent spending, students in the Province of Ontario have under-performed on standardised tests relative to their peers in Quebec, Alberta and British Columbia for the past 25 years (Education Quality and

Accountability Office, 2007). In addition, rural schools in Ontario successfully graduate a smaller proportion of their students and the proportion of graduates from rural schools who pursue tertiary education is lower than for urban schools (Ontario Ministry of Education, 2003). Peru shows similar trends at the department and provincial levels and with respect to the urban and rural divide. As discussed, the level of well-being in Peru is highly skewed in favour of the largely *Mestizo* population living in the capital city of Lima and other major cities, whereas most rural and peri-urban populations live in extreme poverty. Similarly, factors that affect education quality (e.g., budgets, teacher training, youth labour, lack of meaningful employment, etc.) vary from location to location throughout Peru, and are also skewed along the same socio-economic and cultural lines.

Important disparities in the underlying population can only be revealed by analysing the source microdata at geographically local levels. Consequently, while the adoption of EFA recommendations into national priorities within Peru have established education as a development priority, effective planning to achieve the goals of EFA must take into consideration variable conditions at the local (community and school) level. To do this, education planners and decision-makers need to be able to effectively evaluate spatially variable conditions, assess their impacts on education quality at local levels and choose appropriate planned interventions for the improvement of education quality. This is dependent on the availability of timely, complete and accurate data at low levels of spatial aggregation, such as recommended throughout this thesis. Thus, while there continue to be challenges associated with the collection and use of data in Peru, recent trends indicate that there are increasing opportunities to overcome such challenges. These trends include the relatively widespread adoption of ICTs throughout the country, as well as the increased availability of free and open source (FOSS) software.

Provided the necessary data are available, the challenge is to establish a model of education quality into which the available data may be incorporated, and perform analyses at the school and student levels with the data to assist education planners and decision-makers with understanding the spatial variations in an important process indicator, namely absenteeism. This chapter first summarises how this was achieved with the currently available education and socio-economic data in the Province of Maynas, as well as the sample data collected during field work in the study area, relative to the three objectives of this thesis. This is followed by recommendations for education planning and future research and extensions of the work completed in the thesis.

7.1 Thesis Objectives and Results

The first objective of the thesis was to gain a comprehensive understanding of the role of education in the development of nations and individuals and to assess the effect of absenteeism on the quality of education delivered at the school and student levels. A five-component model of education systems was introduced as a framework for assessing education quality in order to achieve this objective. As this discussion clearly showed, access to education especially in the earliest years can be conclusively associated with enhanced personal social and economic opportunities (as well as an improved state of health) for the individual as well as increased security, democracy and overall well-being for nations. Beyond mere *access*, however, it was conclusively demonstrated that the *quality* of the education delivered, as well as the opportunity to attend school *continuously* without interruption, are both critical considerations in the realisation of these opportunities. Thus, absenteeism, which measures interruptions to the process of education, was subsequently proposed as a valuable indicator which could be used to assess the performance of education systems and the quality of education delivered.

Hence, the second objective of the thesis was to gain a comprehensive understanding of the reasons for and contributory factors to absenteeism, and to assess the effect of absenteeism on the quality of education delivered at the school and student levels, with a focus on the role of childhood morbidity. It was expected that childhood morbidity would be a statistically significant contributor to overall absenteeism within the study area due to the low socio-economic status and extreme environmental conditions of the area. Thus, a spatially-enabled education management information system (s-EMIS) was developed to link education quality, as defined by contextual and scholastic indicators from the education system model developed as part of the first objective, to student absenteeism. This sought to translate existing data collected by the MINEDU and the INEI into meaningful information relative to education quality.

In this thesis education quality was defined generally and inclusively, using the perspective of a regional or national level education policy planner or decision-maker. The TBWA method was adapted as an approach for enabling data on multiple indicators of education quality and contextual social well-being to be evaluated in a way that reflects the perspectives of these education stakeholders. This approach produced an index of education quality at the school level that measured individual school performance on education quality relative to this perspective using the five-component model.

A statistical analysis of the absenteeism sample data revealed that there were clear disparities in absenteeism between urban and rural schools. Multiple forms of statistical analysis such as basic descriptive statistics, OLS regression tests, t-tests and ANOVA were shown to be useful for reporting on absenteeism at the student level by the internal characteristics of the data such as the gender, grade and age of the student. Results from these analyses across the study area showed a general tendency for increased absenteeism at rural schools relative to the schools in the urban portion of Iquitos. In addition the statistical analyses revealed that attrition and grade repetition were significantly associated with absenteeism in the study area.

Disaggregating the data by grade showed that the highest rates of absenteeism tended to occur in the first and last primary grades, for all reasons and for both genders. Overall, it was shown that there was little problem with gender-based absenteeism among the sampled students, which is a significant and positive sign of social progress for Peru in general. Finally, an assessment of the reasons for absenteeism showed that instances of absenteeism due to infectious disease were significantly longer than for any other reason, which carries important implications for education planners as well as health practitioners in the study area.

The third and final objective of the thesis was to examine systematically the spatial patterns that exist in absenteeism within the study area as well as the relationship between education quality and absenteeism. The main objective of this analysis was to understand the underlying processes that lead to absenteeism at the school in the study area and to clarify some of the trends noted during the statistical analysis. This was accomplished using GIS and spatial analytical methods such as Moran's I, the Getis-Ord G, GWR and with the use of qualitative visual assessment of spatial patterns using consistency mapping. These spatial statistics were performed both at the global and local levels. At the global level these tests confirmed the presence of spatial dependencies among the schools on both education quality and absenteeism.

However, the spatial variability in the levels of education quality and absenteeism described by the global analysis methods do not capture local trends effectively. More informative methods for regional and local level education planners, or for national level planners seeking to improve the accuracy and effectiveness of planned interventions in the education system, must be able to take this localised spatial variability into consideration. Thus, the majority of the analysis conducted in the thesis sought to demonstrate the use of several methods for observing localised spatial patterns in the data. For instance, while global statistics produced by both the I_i and G_i validated the presence of spatial dependencies in the data (clustering), they were not able to explain the reasons for, or the spatial patterns of, these dependencies among the schools in the study area.

In particular, the schools were found to be significantly clustered relative to theoretical CSR as required before further tests could be applied to the observations. Subsequently the local Moran's I_i and Getis-Ord G_i statistics were applied to the data to investigate the spatial coincidence of similar absenteeism and education quality values at the school level. Use of the Moran's statistic revealed two clusters in both the absenteeism and the education quality variables. The clusters for each variable were located at the same schools, however the cluster of absenteeism values included more schools. One of these clusters contained the urban schools, and the other contained a small proportion of the rural schools south of Iquitos. The Getis-Ord statistic clarified these results and demonstrated that the urban cluster included the peri-urban schools and was a cluster of relatively low absenteeism and relatively high education quality. The rural cluster by contrast was shown to be a cluster of relatively low education quality and high absenteeism.

The final analysis used GWR to determine which factors contributed to absenteeism at the school level and also to measure the effect of absenteeism on education quality at the individual schools. This analysis corroborated the results of the previous spatial analyses and showed that absenteeism played a more significant role on rural education quality than it did on urban education quality. In addition, visual assessment of the consistency or inconsistency of the local contributions of the independent variables used in the absenteeism predication regression model was conducted using the consistency mapping technique. These methods were also used to identify both the spatial distribution of education quality and the effect of absenteeism on the quality of education delivered at the school level. This allowed general trends, such as the concentration of high or low rates of absenteeism and education quality and of the spatial coincidence of these values to be assessed and discussed relative to the goal of improvement of education quality at the schools in the study area. In particular it was noted that parent's education achievement was a significant predictor of absenteeism in urban Iquitos, and that the rural schools were characterised by higher absenteeism associated with elevated youth labour and the presence of over-age students.

Thus, while the spatial analysis techniques explored in this thesis can provide a significant amount of insight into the spatial patterns and variability of student absenteeism and its effect on education quality for the schools in the study area, there is a great deal more that can be learned. Certainly, the results presented in this thesis suggest that more rigorous collection of important local level data can be of great value to education planners. The absenteeism data provided for the analysis in this thesis were collected outside of the normally collected MINEDU data. Moreover the effect of teacher absenteeism and conditions for teachers, while important in and of itself and likely resulting in a synergistic effect, fall beyond the scope of this thesis. In order for these sorts of analyses to prove useful to education planners and decision-makers in Peru, a more concerted effort would be required from local stakeholders in the education system to both improve the data that are collected, and enhance the abilities of key stakeholders to make effective use of these data in a timely fashion. The next section discusses recommendations for education planning that have resulted from the discussion and analysis in this thesis.

7.2 Recommendations and Directions for Future Research

The analyses conducted in this thesis are dependent on a small sample of schools within the study area. They are also dependent on an education quality index based on the assumed perspective of an education planner or decision-maker. The validity of results discussed in the previous chapter would benefit significantly from input from local stakeholders in the Peruvian education system, especially with respect to the development of the education quality index in Appendix B. As noted, this index is only one possible index that could be produced from the available indicators, and as such could be made more relevant and meaningful with professional and expert input from MINEDU education planners and other stakeholders in the education system. While this would require a large investment of time for all stakeholders, the results of this thesis show the clear value of the data already collected by the MINEDU and the INEI, which can only be enhanced by dedicated efforts on the part of education system stakeholders. In addition this thesis would benefit from a more thorough reading of the Peruvian educational literature produced by the MINEDU and other organisations such as local education-focussed NGOs.

Following from this, a second area that requires further effort and resources is the collection and reporting of appropriate and relevant data to assess education quality and the state of the education system effectively, especially at the local school and community levels. The requirements outlined in this thesis for acquiring, processing and analysing the existing data on education and context in Peru demonstrate that there are significant barriers to effective and timely use of the data due to issues of capacity and resources. Moreover, although the available data are extensive in terms of the number of indicators available, their quality, especially with respect to completeness for rural and remote schools and communities, currency, and accuracy remain limited. For example, only two variables in all of the databases acquired are related to outputs from the education system in Peru, while no data are available for evaluating the ultimate outcomes after students graduate and enter civil society (apart from measures of adult and youth literacy).

These issues can only be addressed through improved methods of data collection, storage and distribution which can take advantage of the increasing penetration of ICTs in Peru. Enhancement of central databases with ICTs and related technologies can provide the infrastructure necessary to support statistical analytical tools. In addition, there is a clear need to impress upon education stakeholders the value of and need for accurate, complete and timely data collection. As noted earlier there is an inherent disincentive on the part of local education stakeholders, namely teachers, who see data collection as an imposed burden from which they receive no benefit (and no remuneration as is the case in the study area). Clearly, teachers need to understand the benefits of and reasons for data collection in order to institutionalise the practice. As discussed, this requires a reciprocal flow of relevant and useful knowledge to the teachers based on the data they collect and report to the MINEDU.

This can only be accomplished, however, with the support of key players in Peruvian education, such as the *Sindicato Unitario de Trabajadores en la Educación del Perú* (SUTEP), an education workers rights union. However, SUTEP and the MINEDU are often in opposition rather than collaboration. For example, in June of 2007 SUTEP organised a national teacher's strike opposing a new law that sought, among other things, to impose penalties on teachers who fail MINEDU administered professional teaching examination after subsidised training (*Sindicato Unitario de Trabajadores en la Educación del Perú* , 2007). As discussed previously, teacher accreditation is a serious issue in Peru, especially in rural areas, that is clearly linked to education quality at the local level. Subsidised training and ongoing education of teachers provides the MINEDU with a forum to inform teachers not only of the need for and value of the data they report, but also the opportunity to pass on new knowledge and information to teachers derived from these data. Thus, there is clear value in these institutions working together to increase the quality of education delivered by the MINEDU.

The results from the spatial analysis of absenteeism and its effect on education have confirmed that there are observable spatial processes taking place in the study area which are likely reflected throughout the education system in Peru. However, a framework for translating the results from these kinds of advanced analyses into planned interventions that are sensitive to the local contexts of school and communities needs to be developed. Improved efficiency and effectiveness in the development and implementation of strategies, goals and plans are a clear objective of the MINEDU (and any political agency) considering the financial constraints they face. Thus, for example, targeting specific locations for specific programs (e.g., implementation of a bed net program for rural areas with high rates of malaria) can be accomplished by identifying clusters of schools where very high rates of absenteeism due to infectious disease are reported.

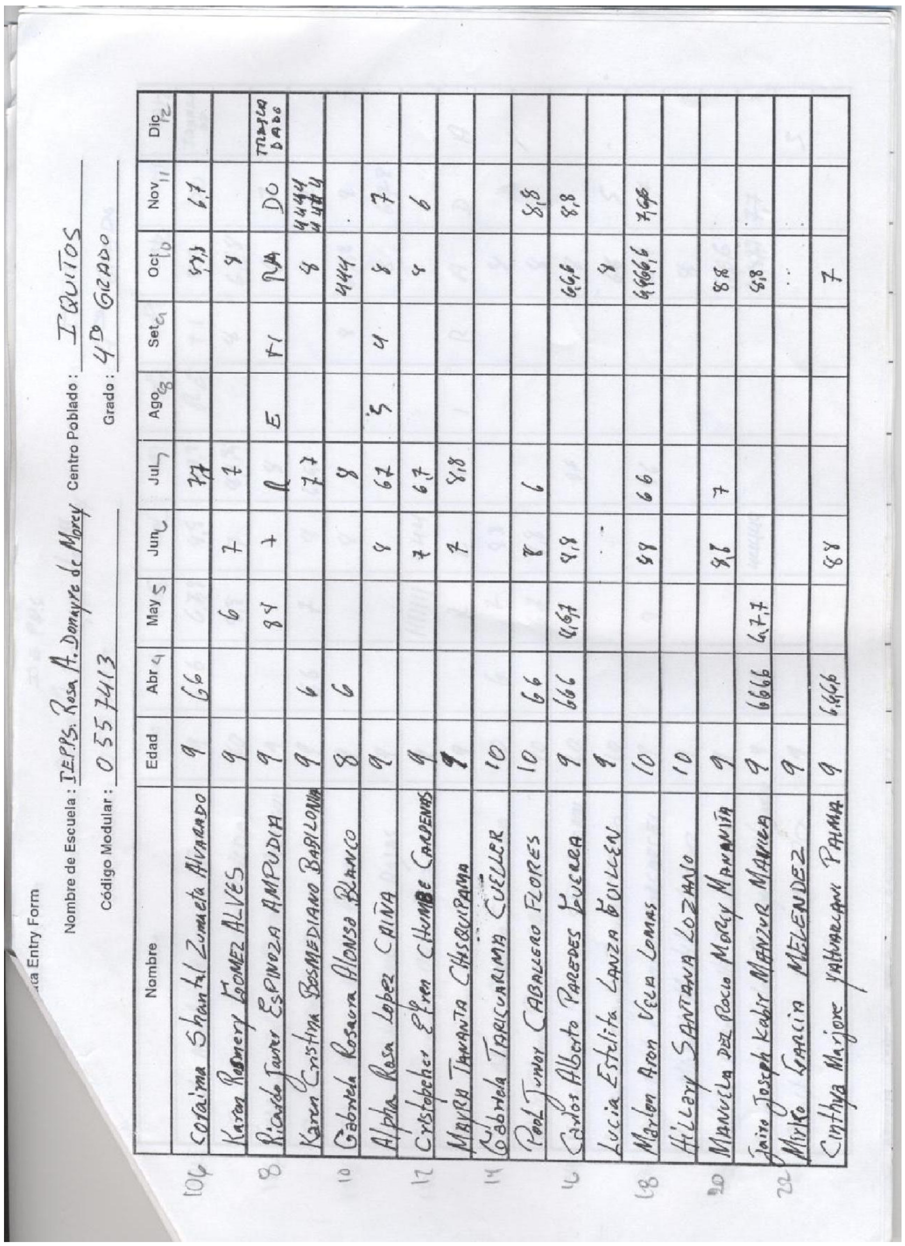
Results such as those presented in this thesis show the value and insight that can be obtained from the data already being collected by the MINEU and the INEI when applied to a targeted and focussed study. For example, results from GWR analysis can be used to identify schools that have a weak or negative relationship between absenteeism and the surrounding socio-economic and environmental context which may indicate the presence of other confounding processes that mitigate absenteeism (such as interventions by aid organisations or the proximity of communities and schools to health facilities). It also might be of interest to examine more closely the characteristics (such as youth labour, and the presence of over-age students) of these schools and communities to learn why they perform well within urban contexts, or perform poorly in rural contexts. The findings from subsequent analyses of these schools could reveal strategies that could be applied to other schools in similar situations in other parts of the country sharing a similar development profile as the study area.

Further, it is important to note that today's students are tomorrow's parents. The educational experience of students currently attending school in Peru will shape not only their future opportunities but also their future attitudes towards the benefits of education for their own children. In addition, as noted previously, the educational attainment of one generation corresponds to improved health of the next. The spatial analyses conducted in this thesis reinforce this by showing that the rate and duration of instances of absenteeism for health reasons are inversely correlated to parent's education achievement (in this case the percentage of parents who completed primary school). This suggests the presence of intergenerational effects that are temporal as well as spatial which need to be understood in order to improve the education experience of children in Peru by promoting continuous and interrupted access to education of a high quality.

Finally, further exploration of the analysis of absenteeism and its effect on education quality can incorporate time as an additional dimension considering that the MINEDU conducts the *Padrón* and the *Censo Escolar* on a bi-yearly cycle and that the results of the 2005 national census conducted by the INEI will be available soon. In conjunction with systematic collection of an absenteeism indicator (as developed in this thesis) this would allow for monitoring changes in absenteeism rates and education quality over time, as well as allow education planners to study the impacts of policies and interventions to the education system. Adding more relevant data at the school and student levels would also create greater potential for the use of spatial analysis techniques (which would require a much larger sample of schools and students) to study the distribution of absenteeism and its effect on education quality. Change in the effect of absenteeism on education quality, for example, could be evaluated using cluster and autocorrelation analysis techniques as discussed in this thesis. Any significant patterns of change identified could be compared against spatially targeted policies or development plans, enabling more effective impact assessments over time.

The topics of discussion in this thesis identify several opportunities for future research that could examine the underlying social and health processes that lead to absenteeism, and thus ultimately contribute to increases in education quality through a reduction of this detrimental factor on continuous education. Since the EFA conference in 1990, the challenge of achieving UPC has remained a priority of international development organisations and donor nations, and most recently, the specific themes of education quality and the continuous nature of education processes have come into focus internationally as critical issues. Due to the efforts of the international community, developing nations such as Peru are making continued efforts to improve their education systems, and more frequently these nations are collecting and maintaining relevant and appropriate data for monitoring of these systems. At the same time, the necessary technologies and knowledge for development of improved education information systems for education planning currently exist and are becoming more readily available in developing countries. What is required at this point is a stronger understanding of the local nature and spatial variability of the underlying processes and that produce absenteeism as well as the processes that reduce the quality of education received by the children of countries such as Peru.

Appendix A
Absenteeism Data Entry Sheet



...ta Entry Form

Nombre de Escuela : IEPPS. Rosa A. Donayre de Morey   Centro Poblado : IQUITOS

Código Modular : 0557413   Grado : 4TO GRADO

Nombre	Edad	Abr 4	May 5	Jun 6	Jul 7	Ago 8	Set 9	Oct 10	Nov 11	Dic 12
Coraima Shantal Zumaeta Alvarado	9	66			77			77,1	6,7	
Karen Rosmery Gomez Alves	9		6	7	7			8		
Ricardo Javier Espinoza Ampudia	9		84	7	R	E	TI	RA	DO	TRASLADADO
Karen Cristina Bosmediano Babilonia	9	6			77			8	4444 4444	
Gabriela Rosaura Alonso Blanco	8	6			8			444		
Alpha Rosa Lopez Caiña	9			8	67	5	4	8	7	
Cristopher Efren Chumbe Cardenas	9			7	6,7			8	6	
Mayra Tananta Chasquipama	9			7	8,8					
Gabriela Taricuarima Cueller	10									
Pool Junior Caballero Flores	10	66		8	6				8,8	
Carlos Alberto Paredes Guerra	9	666	4,67	8,8				66,6	8,8	
Lucia Estelita Lanza Guillen	9							8		
Marlon Aron Vela Lomas	10			88	66			4466,6	7,66	
Hillary Santana Lozano	10									
Manuela del Rocio Morey Manania	9			8,8	7			88		
Jairo Joseph Kabir Manzur Manuca	9	6666	4,7,7					8,8		
Mirko Garcia Melendez	9									
Cinthya Marjorie Yahuarcani Palma	9	6,666		88				7		

Appendix B

Education Quality Index

Education Component	Indicator Description	Null	Minimum	Maximum	Target	Weight
Context	Percentage of children with parents who speak Spanish	-	0	100	100	5
	Percentage of children with parents who work	-	0	100	100	3
	Percentage of children with parents who completed primary education	-	0	92.31	92.31	1
	Percentage of children with homes classified as improper	-	0	100	0	1
	Percentage of the population that completed university	-	0	16.279	16.279	10
	Percentage of the population with official professions	-	0	97.87	97.87	3
	Percentage of youth aged 15 and under who work	-	0	56.13	0	8
	Percentage of homes with a sanitary connection	-	0	100	100	2
	Percentage of homes with water connection	-	0	92.83	92.83	1
	Percentage of homes with poor or improper construction materials	-	0.395	0.916	0.916	2
	Average wealth index	-	0.044	0.305	0.305	4
	Average nutrition index	-	2	3.58	2	1
Inputs	Number of students per teacher	-	9	45	20	3
	Number of official school days per year	-	119	213	213	2
Outcomes	Percentage of children with parents who can read	-	0	100	100	8
Processes	Estimated apparent desertion ratio for grade 1 boys	0.1372	0	0.6	0	0.0833
	Estimated apparent desertion ratio for grade 1 girls	0.1378	0	1	0	0.0833
	Estimated apparent desertion ratio for grade 2 boys	0.0837	0	1	0	0.0833
	Estimated apparent desertion ratio for grade 2 girls	0.0786	0	1	0	0.0833
	Estimated apparent desertion ratio for grade 3 boys	0.0794	0	0.66	0	0.0833
	Estimated apparent desertion ratio for grade 3 girls	0.0776	0	1	0	0.0833
	Estimated apparent desertion ratio for grade 4 boys	0.0787	0	1	0	0.0833
	Estimated apparent desertion ratio for grade 4 girls	0.0769	0	0.66	0	0.0833
	Estimated apparent desertion ratio for grade 5 boys	0.0810	0	1	0	0.0833
	Estimated apparent desertion ratio for grade 5 girls	0.0822	0	1	0	0.0833
	Estimated apparent desertion ratio for grade 6 boys	0.0702	0	1	0	0.0833
	Estimated apparent desertion ratio for grade 6 girls	0.0835	0	0.5	0	0.0833
	Males of appropriate age enroled in grade 1	74.2976	0	100	100	0.0833
	Females of appropriate age enroled in grade 1	72.6687	0	100	100	0.0833
	Males of appropriate age enroled in grade 2	50.1272	0	100	100	0.0833
	Females of appropriate age enroled in grade 2	49.6603	0	100	100	0.0833

Education Component	Indicator Description	Null	Minimum	Maximum	Target	Weight
	Males of appropriate age enroled in grade 3	33.2839	0	100	100	0.0833
	Females of appropriate age enroled in grade 3	33.8764	0	100	100	0.0833
	Males of appropriate age enroled in grade 4	26.9362	0	100	100	0.0833
	Females of appropriate age enroled in grade 4	27.4554	0	100	100	0.0833
	Males of appropriate age enroled in grade 5	23.3218	0	100	100	0.0833
	Females of appropriate age enroled in grade 5	23.1685	0	100	100	0.0833
	Males of appropriate age enroled in grade 6	20.8980	0	100	100	0.0833
	Females of appropriate age enroled in grade 6	21.3841	0	100	100	0.0833

Appendix C
Glossary of Acronyms

AIR	Apparent Intake Rate
ANOVA	Analysis of Variance
CCPP	Rural Population Centres (*Centros Poblados*)
CRC	Convention on the Rights of the Child
DFA	Dakar Framework for Action (2000)
DRE	Regional Education Management Unit (*Dirección Regional de Educación*)
EDF	Empirical Distribution Function
EDI	Education Development Index
EFA	Education for All
EMIS	Education Management Information Systems
EQAO	Education Quality and Accountability Office
ESU	Education Statistics Unit
ESRI	Environmental Systems Research Institute
FOSS	Free and Open Source Software
FTI	Fast Track Initiative (2004)
GDP	Gross Domestic Product
GER	Gross Enrolment Ratio
GIS	Geographic Information Systems

GNP Gross National Product

GWR Geographically Weighted Regression

HDI Human Development Index

HFA Alma Ata Health for All Conference (1978)

HIV/AIDS Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome

ICO Institutional Control Office

ICT Information and Communication Technology

ILO International Labour Organisation

ILS International Symposium for Literacy

IMF International Monetary Fund

INEI National Statistics and Information Institute (*Instituto Nacional de Estadística e Informática*)

LAC Latin America and the Caribbean

MAR Missing at Random

MDGs Millennium Development Goals

MINEDU Peruvian Ministry of Education (*Ministerio de Educación*)

MDG Millennium Development Goals

MNAR Missing not at Random

MRTA Tupac Amaru Revolutionary Movement

NER Net Enrolment Ratio

NGOs Non-governmental Organisations

NIR	Net Intake Rate
OGC	Open GIS Consortium
OLS	Ordinary Least Squares
s-EMIS	Spatially-enabled Education Management Information System
SITs	Spatial Information Technologies
SLSN	Single Line Street Network
SQL	Standard Query Language
SUTEP	*Sindicato Unitario de Trabajadores en la Educación del Perú*
TBWA	Target-based Weighted Average
UDHR	Universal Declaration of Human Rights
UGEL	District Education Management Unit (*Unidad de Gestión Educativa Local*)
UK	United Kingdom
UMC	Unit of Education Quality Measurement
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational Scientific and Cultural Organisation
UNESS	United Nations National Education Support Strategy
UNICEF	United Nations Children's Fund
UNMD	United Nations Millennium Development
UPC	Universal Primary Completion

UPE Universal Primary Education

US United States

VD Voronoi Diagram

WB World Bank

WCEFA World Conference on Education for All, Jomtien Thailand

WHO World Health Organization

WVD Weighted Voronoi Diagram

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