ENVIRONMENT AND HEALTH IN CENTRAL ASIA : QUANTIFYING THE DETERMINANTS OF CHILD SURVIVAL

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ENVIRONMENT AND HEALTH IN CENTRAL ASIA: QUANTIFYING THE DETERMINANTS OF CHILD SURVIVAL

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A THESIS SUBMITTED TO THE UNIVERSITY OF ST. ANDREWS FOR THE DEGREE OF PH.D. IN THE FACULTY OF ARTS

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ABSTRACT

The impact of environmental degradation on well-being is largely ignored in terms of economic costs of development. Due in large part to measurement difficulties, the environment in the daily welfare of the world's poorest remains inadequately accounted for in development policies. The aim of this work is, therefore, to advance our understanding of the relationship between the environment and human health. Anthropogenic activities in Central Asia have severely disrupted the natural environment. The poorest, most vulnerable members of society are at an increased risk of mortality and a life-time of illness associated with worsening ecological conditions in the region. The work is by nature inter-disciplinary and pulls from many social sciences in an attempt to provide new insight into the role of long term environmental degradation and the impact on social welfare.

There are three main original contributions of this work. Firstly, the research demonstrates the traditional emphasis in the literature on socioeconomic factors in explaining high rates of child mortality in Central Asia is inadequate. Secondly, for the first time in an international cross-section examining the determinants of child survival, the macro-level environment is put forth as a key determinant of excess child mortality in Central Asia. An improved measure of income is used for the first time in such a study to control for important distributional effects within and between countries. The results confirm the hypothesis that traditional determinants do not account for endemically high rates of mortality in the region. Secondly, using administrative (*oblast*) data from Uzbekistan, Chapter 6 presents the first study of its kind to incorporate important geographic as well as socioeconomic information in explaining variation in infant mortality due likely to ecological degradation. Ultimately, the findings demonstrate the environment must be adequately considered in all policy making aimed at improving health outcomes in the region.

I, Jennifer Sue Franz, hereby certify that this thesis, which is approximately 60, 831 words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

Date   Jennifer Sue Franz

I was admitted as a research student in September, 2003 and as a candidate for the degree of Ph.D. in September, 2003; the higher study for which this is a record was carried out in the University of St. Andrews between 2003 and 2006.

Date   Jennifer Sue Franz

I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate for the degree of Ph.D. in the University of St. Andrews and that the candidate is qualified to submit this thesis in application for that degree.

Date   Professor Felix FitzRoy

DECLARATION

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ABBREVIATIONS

ADB	Asian Development Bank
ARI	Acute Respiratory Infection
ASB	Aral Sea Basin
CARs	Central Asian Republic
CEE	Central and Eastern Europe
CIS	Commonwealth of Independent States
CMORT	Child Mortality
COI	Cost of Illness
CP	Consumption of the Poor
CPE	Centrally Planned Economy
DALE	Disability Adjusted Life Expectancy
DDT	Dichlorodiphenyltrichloroethane
DHS	Demographic and Health Surveys (Measure DHS)
DPSEEA	Driving forces, Pressure, State, Exposure and Effect, Action
EBDR	European Bank for Development and Reconstruction
EHI	Environmental Health Indicators
FAO	Food and Agricultural Organisation
fSU	Former Soviet Union
GDP	Gross Domestic Product
GNI	Gross National Income
GNP	Gross National Product
HALE	Health Adjusted Life Expectancy
HEADLAMP	Health and Environment Analysis for Decision-making
HDI	Human Development Index
IAP	Indoor Air Pollution
ICAS	Interstate Council for the Aral Sea
ICD	International Classification of Diseases
ICG	International Crisis Group
IFAS	International Fund for the Aral Sea
IMF	International Monetary Fund
IMR	Infant Mortality Rate
IWCW	The Interstate Coordinating Water Commission
LAS	Large Aral Sea
LPG	Low Polluting Gas

MDG	Millennium Development Goal
MDHS	Measure-Demographic and Health Survey
MEME	Multiple Exposure Multiple Effects
MMT	Million Metric Tonnes
MOH	Ministry of Health
NAR	Net Attendance Ratio
NAS	Northern Aral Sea
NEHAP	National Environmental Health Action Plan
NGO	Non-Governmental Organization
NIS	Newly Independent States
PPP	Purchasing Power Parity
RI	Respiratory Illnesses
TB	Tuberculosis
U5MORT	Under-5 Mortality
UHES	Uzbekistan Demographic and Health Survey
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNICEF	United Nations International Children's Emergency Fund
USA	United States of America
USAID	United States Agency of International Development
USEPA	United States Environmental Protection Agency
USSR	Union of Soviet Socialist Republics
WB	World Bank
WHO	World Health Organization
WRI	World Resources Institute

1 INTRODUCTION

1.1 INTRODUCTION

The success of economic policies is traditionally measured in terms of economic growth. Increasing income per capita is generally the measure of this growth and viewed as the pathway to improved welfare and living standards within a society. Welfare, however, is intrinsically difficult to quantify and value; like natural capital, it depends on who is doing the measuring and to which aim. The international community has agreed gains in welfare should be "sustainable" and to this end an overarching framework has been established to addresses the social, ecological and economic components of development. Although it is widely agreed sustainable development is a necessary and fundamental objective for the international community, measuring the success of its components is less widely agreed upon. Furthermore, the means by which economic growth is traditionally measured remains a fundamental impediment to achieving sustainable development goals.

Traditional indicators of well-being, such as income per capita and life expectancy, are incomplete measures of living standards. More "multidimensional" measures which incorporate a series of social and economic components have therefore been proposed, such as the Human Development Index (HDI) which weights numerous indicators to establish varying levels of development. The Health Adjusted Life Expectancy (HALE) and Disability Adjusted Life Expectancy (DALE) are indicators of well-being which adjust ones life expectancy based on quality of living—not just quantity. Likewise, a series of "green" indicators have been constructed to improve upon the accounting of resources, including genuine investment or genuine savings, as traditional measures of economic growth, normally calculated as per capita gross domestic or national product (GDP or GNP), ignore fundamental depreciation and/or consumption of natural resources.

A primary need for augmented measures of welfare and growth is to include the environment and its services. Traditional indicators do not recognise the complex pathways linking population growth, economic activity and the state of the natural resource base (Daily et al, 1998; Dasgupta, 2003, Hamilton, 1999). Mapping the interactions of the three pillars of sustainable development is what ultimately challenges traditional economics and presents fundamental questions for neo-classical theories that have largely ignored the inherent limitations of the environment. Traditional "economic failure", where all costs are not fully captured, occurs as existing markets do not reflect the true value of natural resources, due either to missing markets or distortions from government actions (Pearce and Moran 1994).

Two branches of neo-classical economics that try to correct for standard market failure and distortions with respect to the environment and its services are environmental and natural resource economics. Environmental economics measures what the economy inserts into the environment, while natural resource economics focuses on what the economy extracts from the environment. Both these sub-disciplines of neo-classical economic theory do not necessarily address ecological and economic interactions, i.e. the cost of reduced social welfare due to ecological degradation resulting from resource use. Ecological economics has tried to a significant degree to fill this gap in addressing the relationship between economic and ecological systems and specifically human activities impacting on the natural environment and, in turn, the negative implications this has for future generations (Common and Stagl 2005). Ecological economics addresses the relationship between ecosystems and economic systems in the broadest sense (Costanza 1989). Tisdell (2003) emphasises:

"…ecology and economics needs to be linked, and this requires cooperation between ecologists and economists and a more open approach than hitherto on the part of the economists to the often all-pervasive environmental issues" (p. 364).

Ecological economics is inherently issue oriented and interdisciplinary and, like this work, is concerned with problems which naturally cross disciplinary boundaries. Measuring the link between pressures on ecosystem services and resulting declines in social welfare has remained largely ignored in terms of economic costs of development due to the many political, economic and social problems which place increasing pressure on the environment. Due also to measurement difficulties, the role of the environment in the daily lives and welfare of the worlds poorest remains inadequately considered in development policies.

The benefits of improving environmental health and, in turn, social well-being are self-evident. What remains challenging for accounting purposes, therefore, is the identification and quantification of ecological externalities on social welfare and in turn, on economic productivity. The link between these factors must be established to allow for a more comprehensive valuation of losses. To this end, the work within this thesis is taking a first step in identifying and quantifying externalities from environmental pollution and the indirect impacts on human health and well-being. The findings within this research support the fact that the traditional emphasis in the literature on socioeconomic factors in explaining high rates of child mortality in Central Asia is inadequate in light of the severe ecological degradation in the region. Results from an empirical investigation of 61 developing and transitional economies are reported and demonstrate for the first time in such an analysis that traditional determinants do not fully account for endemically high rates of mortality in the region. Further evidence of this link is offered in a country-level analysis of Uzbekistan using administrative (*oblast*) data; important geographic as well as socioeconomic information are found to explain variation in infant mortality due likely to ecological degradation. Ultimately the findings demonstrate the environment must be adequately considered in all policy making aimed at improving health outcomes in the region,

1.2 BACKGROUND

During the last fifteen years of independence the Central Asian Republics (CARs) have experienced a severe socioeconomic decline, measured by indicators of well-being, including an increase in poverty, growing asymmetry in income distribution and reduced life expectancy. The CARs, when combined with their neighbour Azerbaijan, cover an area roughly equivalent in size to India, Pakistan and Bangladesh. In contrast to the over 1 billion people living in these three countries, the CARS have approximately 65 million people—roughly the population of France. While the vast land area constitutes significant heterogeneity in geography, demography and natural resources, the CARs share a common history of Soviet legacy which sets them uniquely apart from other transition and developing countries and this may largely explain their relative absence in this literature (Falkingham, 1999).

Soviet Central Asia, and the other former Soviet Republics (fSU) receive much less attention than other developing and transition economies and there remains remarkably little written about the economic policies of these countries inhibiting sustainable and equitable development in the region. The dramatic social and economic upheaval which accompanied the collapse of the Soviet Union has dominated scholarly interest in the post-Soviet period, while environmental concern is generally marginalised to the infamous loss of the Aral Sea and the ecological and biological impacts associated with its disappearance.

The Aral Sea disaster has been labelled by the United Nations as one of the greatest environmental disasters of the 20th century. The most imminent threats to ecological and thus human health from the disappearing Aral Sea include:

Worsening dust storms from the drying of the sea-bed and the contaminated, toxic makeup of airborne particles

Worsening salinity of the soil and agricultural lands
Shortage of potable water, i.e. water not contaminated with salts and other chemicals
Contamination of water, soil and food from agro-chemical applications
Reduced socioeconomic conditions due to the high reliance on cotton monoculture, including occupational hazards, high unemployment and poor planning
Climate change linked to advanced desertification (contributing to rising temperatures and thus poor yields)

Diseases widely linked to poor environmental conditions within and without the household dominate overall mortality in rural Central Asia. Nearest the Aral Sea, rates of common infectious diseases are amongst the highest in all of the fSU; such illnesses include anaemia, tuberculosis and respiratory infections. Within the Aral Sea Basin (ASB), deaths from digestive and respiratory diseases account for a dominant share of adult and child mortality.[1]

Despite the undisputed and irreversible impact of the agricultural sector in bringing about severe environmental degradation, the causal link between this sector and health in the CARs remains widely over-looked in the literature on the CARs. Linking environmental degradation to human health is neither linear nor are there direct dose-response indicators available to capture the precise effects of long term environmental degradation from this sector on well-being. Compounded with unreliable data and few previous studies in the area, investigating the causal chain between policies resulting in ecological degradation and the ultimate implications for social stability poses many complex issues and crucial areas of query.

1.3 RESEARCH OBJECTIVES

The purpose of the following research, therefore, is to advance our understanding of the link between environmental degradation resulting from the agricultural industry and the impact on socioeconomic sustainability, measured by child survival. Throughout this work, child mortality is used for both infant and under-5 mortality, unless otherwise indicated. The work naturally demands an inter-disciplinary approach. Historically, the reluctance of academic disciplines to come together has inarguably inhibited much progress and discussion on the issues raised by the economic, social and environmental factors determining sustainable and equitable development in the region.

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[1] The Aral Sea Basin (administratively) is approximately 2 million km^2 in size and includes all of Uzbekistan and Tajikistan, portions of Kazakhstan, Kyrgyzstan, and Turkmenistan; also part of north Afghanistan and northeastern Iran.

There are two main objectives of the research: the first is to advance our understanding of the cause of high child mortality in Central Asia, in general, and Uzbekistan in particular—the most cotton-intensive republic in the region. The second main objective is to explore the role of macro-level environmental degradation in explaining child mortality in the face of poor data availability, quality and myriad measurement difficulties. The severity of environmental degradation in Central Asia has become accepted as irreversible. Externalities associated with widespread air, water and soil pollution have likewise become widely accepted, albeit undervalued and poorly understood. Child mortality in Central Asia has been "endemically" high as far back as the data allow us to look. Based on current income levels and the economic upheaval in the region, perhaps high mortality should not be a surprise as it is a widely accepted indicator of socioeconomic welfare. However, other indicators of living standards such as literacy rates (achieving 99% in some republics which exceeds many of the most developed countries) and life expectancy historically in line with other Western industrialised nations, do not support traditional explanations of determinants of child mortality. Furthermore, rates of child mortality were consistently higher in the USSR than in other European countries during the Soviet period. Rates within Central Asia have long-exceeded those in the other fSU countries, both before and after independence. The traditional determinants of child survival simply do not fully explain why high child mortality in the region is so prevalent and perhaps more importantly why such high rates, sometimes 8 to 10 times higher than in Western Europe and other industrialised countries, have commanded relatively little attention worldwide compared to sub-Saharan Africa and other developing regions.

There are generally three categories of determinants of child survival explored in the literature: socioeconomic, health care and environment factors within the household. With regards to Central Asia, however, environmental factors, and specifically macro-level environmental factors as determinants of high levels of mortality, have been largely overlooked—despite having what the United Nations has referred to as one of the greatest environmental disasters of all time.

The CARs are an important sub-region of the fSU as they are highly reliant on the agricultural sector and specifically, the monoculture production of cotton. Cotton production, a resource-intensive crop, brought about the desiccation of the Aral Sea and yet it continues to dominate the economies of Tajikistan, Turkmenistan and Uzbekistan and is grown throughout Central Asia and Azerbaijan. Therefore, poverty, the environment and short term political and economic interests are pulling in competing directions and at the same time all contributing to a cycle of poor environmental and ultimately human health.

1.4 STRUCTURE OF THE THESIS

To address the aforementioned research objectives, the thesis is structured into 7 chapters, including the introduction and conclusions. Following this introduction, Chapter 2 introduces the problem of health inequality and the role of the environment in explaining a share of this inequality within and between populations. The methodology used to link environmental degradation to health outcomes is then introduced and, in particular, the relationship between environmental factors and their importance in determining child survival is established. The role of traditional and modern health hazards is discussed and the term "environmental health" is introduced. The level of analysis used throughout this research is at the ecological or macro level and Chapter 2 addresses both the benefits and difficulties of exploring environmental health issues at this level. Chapter 3 focuses the research on the environmental health issues of key interest in the Central Asian Republics: namely monoculture cotton production. This chapter discusses both the economy of monoculture cotton production which began during the Soviet period and continues today, along with the unique environmental externalities resulting from its production. The need for social policies to address environmental degradation in any comprehensive goal towards sustainable and equitable development in the region is discussed. Chapter 4 introduces the role of environmental degradation as a main factor explaining endemically high rates of child mortality in the region. Historical social, economic and ecological factors are discussed in relationship to child mortality; the unique ecological factors are put forward as key determinants of poor child survival throughout the CARs. Chapter 5 is the first of two empirical chapters in the thesis estimating a wide range of determinants in explaining child survival in the CARs. In this chapter a cross-country approach is used, incorporating 61 developing and transition economies, to explore the role of traditional determinants in explaining high child mortality both in the entire sample and uniquely in the CARs. Evidence of excess mortality linked to environmental degradation is put forth as a main finding of the analysis. Focusing specifically on Uzbekistan, in Chapter 6 regional data are used to investigate the role of traditional and spatial factors in explaining variation in mortality. A large degree of omitted variable bias present in Chapter 5 is avoided in Chapter 6 and the results support our hypotheses that environmental factors in Uzbekistan explain some variation in health outcomes in the country. Chapter 7 summarises the findings and discusses directions for future research in the area.

2 ENVIRONMENTAL HEALTH AND ECOLOGICAL LEVEL ANALYSIS

ABSTRACT

The purpose of this chapter is to introduce the methodology used to link environmental degradation to child mortality. The importance of identifying health inequalities within and between groups is first addressed, motivating the exploration of environmental health in the work. The term "environmental health" as it is used in the literature is introduced and the role of traditional and modern health hazards are discussed, as is the difficulty in linking health risks to environmental pollution at the macro-level. The role of child mortality as an indicator of environmental health is introduced and ecological analysis is put forth as an appropriate level at which to investigate environmental and health relationships in the CARs. The methodological applications and problems confronted in subsequent analysis are introduced and the final section concludes.

2.1 INTRODUCTION

The impact of environmental degradation on human health has gained increased attention in recent years. Environmental pollution and the threat posed to human health is most pressing in developing countries, particularly access to potable water, adequate sanitation, and the impact of indoor and outdoor air pollution. In a seminal text on the role of the environment in economic and social well-being, Pearce and Warford (2003) argued “the most important and immediate consequence of environmental degradation in the developing world takes the form of damage to human health” (p. 133). The importance of environmental quality in determining child survival has received significant attention in both the developed and developing literature (Briggs 2003, Suk et al. 2003, Kyle et al. 2006). Ensuring environmental quality and therefore health is essential to achieving the World Health Organization’s (WHO) Millennium Development Goals (MDGs) in reducing child mortality around the world (WHO 2002a, Briggs 2003).[2] Particularly in the poorest countries, less attention has been paid to the economic costs of poor health and morbidity associated with environmental damage. One reason for this is that exposure is not readily measured and levels of environmental pollution can vary significantly within a small geographic area, thus making detection of the link between pollution and health imprecise. In countries where conventional economic development dominates environmental concerns, the link between well-being and environmental quality does not receive adequate attention (Corvalan and Kjellstrom 1996). Furthermore, economic interests often drive environmental pollution, thus competing with interests to reduce exposure and improve health outcomes (Dasgupta 2004).

2.2 EXPLORING INEQUALITIES IN HEALTH

A complex set of factors ultimately determine health outcomes and differentials within and between households. Health is defined by the World Health Organization (WHO) as: “A state of complete physical, social, and mental well-being, not merely the absence of disease or infirmity” (WHO, 2007). In the literature, “health inequality” implicitly denotes socioeconomic inequality in health. It is necessary, therefore, to clearly define what is being measured and what differentiation in rates may mean as well as which factors may be causing the variation (Regider 2004).

Variation in health outcomes is prevalent within and between countries, with the poorest populations usually at a greater risk of poor health. Such variation can be due to myriad

[2]Child mortality in this chapter refers to both infant (age 0-1) and under-5 (age 0-5) mortality, unless otherwise stated.

factors, including unaffordable medical care, poor access to facilities, low education levels and greater exposure to high risk activities such as agriculture, and the negative externalities associated with agro-chemical applications, poor water quality, soil and access to quality food stuffs (Musgrove 1993). Inequality in health has been noted in the developed and developing literature alike; there is significant debate as to how health inequalities should be measured (Wagstaff et al. 1991, LeGrand and Phillips 1996a). Health inequality is often cited as a result of poor access to affordable health care in the CARs (See Chapter 4). There are a limited number of quantitative studies focusing on health sector inequality in developing countries, due mostly to data quality and availability at the aggregate level (Makinen et al. 2000). It has been found, however, that the poor devote a larger share of their consumption expenditure on health than the rich (Green et al. 2000).

Many government policies and international efforts at decreasing rates of mortality and thus improving overall health focus on pro-poor public spending as a "catch-all" approach to improving health (Gupta et al. 2003). Such a blunt tool, however, has not necessarily shown to improve health outcomes. In China, for example, advances in mortality reduction over the past 50 years were not significantly correlated with improvement in health resource availability (Prescott and Jamison 1985). Especially in developing and transition economies, poor data on the distribution of health outcomes makes understanding the impact of spending on the poor difficult to differentiate in aggregate-level analysis (Bidani and Ravallion 1997). There is evidence that basic improvements in social services and primary health care can reduce maternal and infant mortality in Central Asia, however, due to the significant variations in completeness, validity and reliability of health data across the region, the effectiveness of policies varies significantly between countries (WB 2004). The role of health care in explaining differentials in rates of morbidity and mortality at the international, regional and even national level are confounded by many other socioeconomic factors that may exacerbate health inequalities, such as education, religion, geographic location and spatial factors, such as population density (Sachs et al. 2001, Balk et al. 2004).

There is significant interest in the role of income on health and the assumed relationship between income distribution and health outcomes. Wide-spread debate surrounds the link between income inequality and health (Wagstaff et al. 1991, Gravelle 1998, Deaton 2003) (Chapter 3). Social factors have been found to be important (Kennelly et al. 2003) as have psychosocial factors such as self-perceived health (Crighton et al. 2003) and social cohesion (Lynch et al. 2001). Caution must be taken in assuming a mono-causal explanation of mortality and poor health—particularly at the aggregate level.

Environmental protection and its importance in policies designed to improve health outcomes and equality is recognised (Marmot 1998; Marmot, 2002). Environmental health plays a particularly acute role in the health of poor rural communities where dependence upon the natural environment is much greater; the survival prospects of poorer members of a society have been cited as a function not only of inequality, but inequity (Kirigia 1997, Wildman 2001, Goesling and Firebaugh 2004). The environment and quality of the environment determined by anthropogenic activities is a primary example of inequity that may ultimately lead to inequality in health outcomes.

Multiple factors impact on the poor to affect health outcomes linked to the environment. For example, less money means a household is less able to afford water, non-polluting heating, access to quality and sufficient food, thereby increasing susceptibility to disease and illness (Victoria et al. 2003). Changes in health outcomes and variation across a particular area are broadly effected by not only economic factors but also changes in the epidemiological environment (Kirigia 1997, Sieswerda et al. 2001). The environmental impacts on human health—also known as the epidemiological environment—are defined by a broad set of variables that are ultimately shaped by development (and global change), including geography, nutrition, land conversion, biodiversity, agricultural intensification and climate change (Daily and Ehrlich 1996). Potential health hazards posed by different environmental pollutants are of significant concern, although many factors are unobserved, under–reported, and/or immeasurable (Best et al. 2000). Furthermore, many health outcomes do not show "smooth" trends across space and over time or within and between populations, thus confounding causal links (Kelsall and Diggle 1998). It is the limitation of data availability and quality that largely prevents much understanding of what determines health differentials within a given geographic, social and economic area. There is a distinct need to pool information across disciplines to understand those factors which ultimately determine health outcomes, combined with ongoing development of methods of measurement to link economic, social and environmental factors impacting on health (Green et al. 2000).

2.3 DEFINING ENVIRONMENTAL HEALTH

Environmental health addresses the relationship between the natural environment and human health outcomes. Exposure to environmental pollution and the impact on human health is well established and human exposure to pollutants, whether via air, water, soil and food, is a main contributor to increased morbidity and mortality around the world (Corvalan and Kjellstrom 1996). Briggs (1999) has defined environmental health as "the presence in the environment of an agent which is potentially damaging to either the environment or human health" (p.27). Factors which reduce environmental health are those "stressors" that impact on human health via normal pathways such as ingestion, inhalation and absorption (Corvalan et al. 1996). Environmental health studies are, therefore, concerned with the negative externalities arising from household and/or activities external to the home that reduce health outcomes at the individual, community or national level (Smith et al. 1999).

2.3.1 Traditional and modern health hazards

Traditional hazards to human health include those linked to poverty and under-development, including poor sanitation, lack of potable water and many other such threats linked to income levels (Corvalan et al. 1999). Modern hazards, on the other hand, are those normally resulting from unsustainable development and the exploitation of natural resources ending in pollution or contamination of the natural environment. Millions of premature deaths occur every year due to modern health hazards, including biological and chemical agents in the environment. Where traditional health risks and their impact on health may be immediately identifiable, modern health risks can take extended periods of time to manifest themselves as a disease and thus are not readily linked to human health. Where poor water quality can surface immediately in the form of diarrhoea, chronic illnesses and/or cancer-causing agents from chemical exposure in the environment may take years to reveal themselves (Corvalan and Kjellstrom 1996).

2.4 IDENTIFYING ENVIRONMENTAL HEALTH RISKS

Environmental health studies are concerned with the "many-to-many" relationships—that is, many potential risks and outcomes that are not easily identifiable, making the causal chain of environmental pollutants to human health imprecise. Due to variation in detecting the impact of environmental pollution on health and the significant variability in exposure and human resistance, Briggs (2003) highlights:

"In general, too little is known either about the causal links between environmental pollution and health, or about the levels of exposure across the population to make reliable assessments of the proportion of disease or mortality attributable to pollution…" p. 15.

The difficulty in linking environmental pollution to human health outcomes is even greater in developing countries. Routinely collected data on environmental quality and monitoring as well as widespread mortality and morbidity data are often limited or non-existent. In an effort to maximise available data and raise awareness on inequality in health threats, an initiative was established in the early 1990's to promote Health and Environment Analysis for

Decision-making (HEADLAMP). The aim of the HEADLAMP project was to improve policy-making by offering information on the link between polluting activities and their externalities and the end result of morbidity and mortality, thus allowing for more informed decision making (Corvalan et al. 1996). The HEADLAMP project was a joint collaboration among the United Nations Environment Programme (UNEP), the United States Environmental Protection Agency (USEPA) and the World Health Organization (WHO). Although the HEADLAMP project is no longer operating (personal communication with Corvalan), the methods and tools for linking health and environmental data provide a useful framework for exploring the relationship between environmental pollution and the impact on health as well as emphasizing the need for greater clarity and broader tools for exploring the environmental health link.

2.4.1 Developing environmental health indicators

The HEADLAMP framework for connecting polluting activities to health outcomes can be seen in Figure 2.1. The Framework establishes a clear pathway for describing the link between a polluting activity and health outcome in the form of an environmental health indicator (EHI). Such measures are defined as:

"An expression of the link between environment and health, targeted at an issue of specific policy or management concern and presented in a form which facilitates interpretation for effective decision making…" (Corvalan et al. 1996) p. 25.

An EHI must be readily understood and relevant to the environment and health concerns of interest (Corvalan, Briggs et al., 1996 p. 27). An environmental health indicator is one way of informing policy makers on the state of the environment and the potential impact on human health. A well-known framework for developing EHIs proposed under the HEADLAMP project is the DPSEEA framework—the Driving Forces, Pressure, State, Exposure and Effect, Action (Figure 2.2). The "Driving forces" approach allows the activities responsible for pressures on the environment and the effects which precede the policy response to be clearly mapped, and thus EHIs to be developed and readily utilised (Corvalan et al. 1996). In order to be considered good indicators, EHIs must be cost-effective to compile and apply (Briggs 1999). The purpose of an EHI is to inform policy-makers and identify where action should be taken to reduce high morbidity and mortality rates.

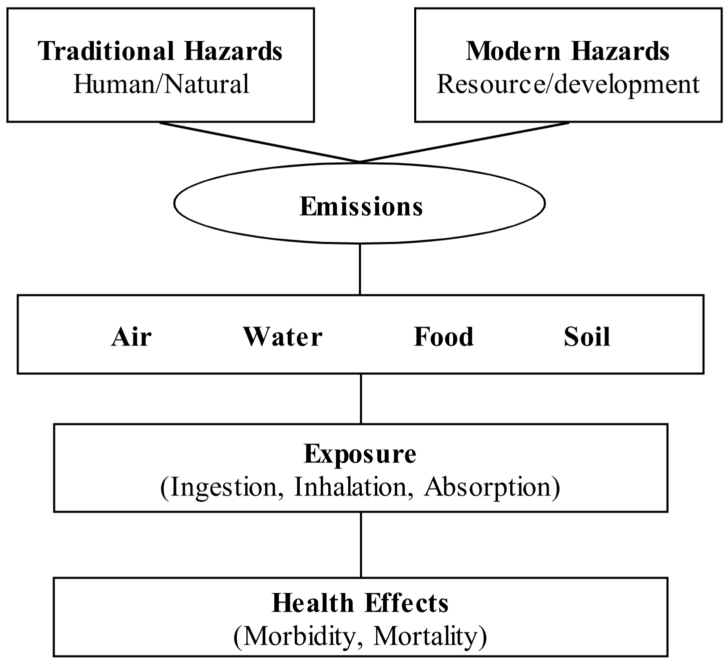


Figure 2.1 Environmental health pathways. Source: Corvalan, 1996

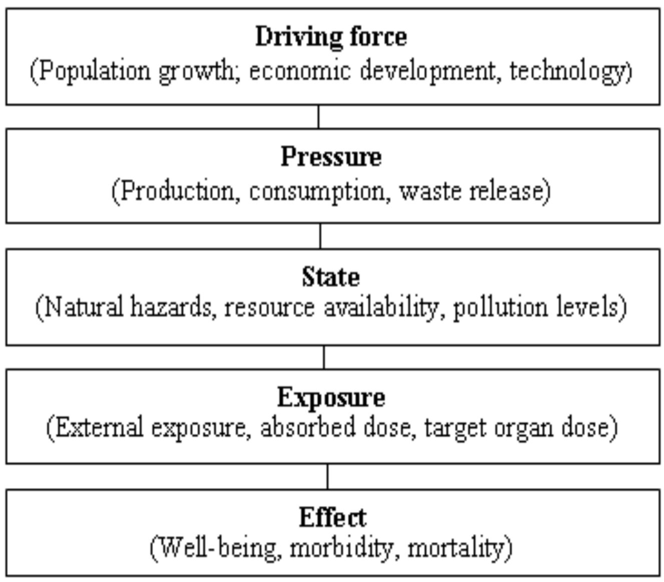


Figure 2.2 DFPSEEA Framework for developing environmental health indicators. Source: Corvalan, 1996

The WHO proposed a slightly altered version of the DPSEEA framework for the construction of EHIs linked to child health outcomes and is referred to as the MEME model or Multiple Exposure Multiple Effects model Figure 2.3 (WHO 2003). The main difference between the two models is the MEME combines the state, pressure and exposure components under a single "exposure" component to simplify the application of the framework. The model is applied by the WHO to identify threats to child environmental health and although this framework can be similarly applied to the adult population, children are generally dealt with separately in the literature. Children are arguably the most vulnerable population to environmental degradation and simultaneously the least capable of protecting themselves; more than 3 million children annually die of environmentally-related illnesses (WHO 2002a).

Environmental health indicators, therefore, capture the relationship identified in Figure 2.1, from a polluting source to human health. Such an indicator allows one to measure the impact from the proposed source of pollution on the health outcome of interest (Figure 2.2). Few indicators attempting to proxy environmental effects on human well-being can be classified as "valid" or "invalid" (Ezzati and Kammen 2002). Instead, indicators are either close to or distant from the health outcome and they can more or less capture a hazard. The validity of a variable increases by proximity to the human health outcome. Making the link between source activities and an identified health effect is uncertain; however, any attempt to quantify an environmental burden of disease, even if an approximate exercise, can be "well worth the effort" (Briggs, 2003, p. 15). When the primary goal is to raise awareness of inequality and variation in health outcomes within a specific area, and with the aim of informing policy, imprecision in linkage methods is not an obstacle, but should rather be a point of consideration within the interpretation and analysis (Corvalan et al. 1996).

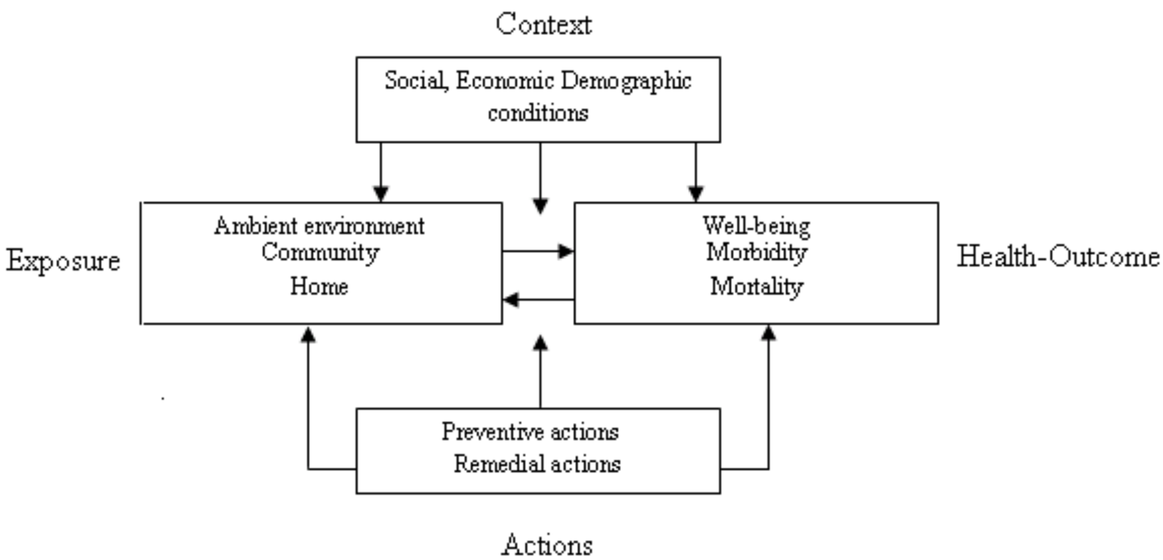


Figure 2.3 Multiple Exposure Multiple Effects (MEME). Source: adapted from WHO, 2003

Deteriorating health in the Aral Sea Basin (ASB) in particular parallels the declining ecological and economic situation, yet modern health hazards, e.g. pesticide consumption, have been less widely considered due in part to poor linkage methods. The interest in identifying a link between environmental pollution and poor human health is to understand what share of poor health is "attributable" to environmental degradation and, therefore, what a reduction in environmental pollution would translate into in terms of improved health outcomes (Smith et al. 1999). In the absence of early warning indicators for the environmental hazards common in the CARS, we will utilise mortality rates by age and cause of death as indicators of environmental health. A key argument for the existence of a "significant environmental risk factor" such as proximity to the Aral Sea or a lifetime of exposure to chemical pollution, is a variation in similar morbidity and/or mortality rates that cannot be readily linked to genetic factors (Smith et al. 1999). It is this variation in health, therefore, that is of concern and signals inequality within and between populations that may be linked to environmental determinants.

2.5 CHILD MORTALITY AS AN ENVIRONMENTAL HEALTH INDICATOR

Following the Briggs framework (Figure 2.1), the health "effects" in which we are specifically interested in explaining are overall child mortality and child mortality by specific cause of death, thus operating as environmental health indicators in Chapters 5 and 6. Child mortality operates as an indicator of environmental health in that the environment is a determinant of child mortality and high rates of child mortality indicate poor social, economic and environmental factors; therefore, we aim to capture the environmental effects impacting on a highly vulnerable group. Child mortality is an "effect-based indicator", thus projecting backwards from the health outcome to give an indication of the environmental cause (an environmentally attributable health outcome). There are two types of environmental health indicators: exposure-based or effect-based. Exposure based indicators project forward some knowledge about an environmental hazard and give an estimated measure of risk. Effect-based indicators, on the other hand, project backwards and give an indication of the environmental cause that may explain a rate of mortality /morbidity that is attributable to environmental degradation. (Corvalan et al. 1996). The purpose of utilising child mortality and child mortality by cause of death is two-fold. Firstly, child survival is a function of many economic, social and environmental variables. We are testing the hypothesis that child mortality in the CARs is partially explained by environmental degradation, after controlling for other more readily measured economic and social determinants. Secondly, as an EHI, overall child mortality, and mortality by cause of death, reveal variation in health outcomes at the population level plausibly linked to environmental degradation, where illnesses may be determined by environmental quality. Overall child mortality and child mortality by cause of death are likewise important indicators of social and economic well-being and thus they fulfil the requirement for EHIs to be important for policy or management; they "relate to aspects of environmental health which are both of relevance to the decision-maker and amenable to control" (Corvalan et al., 1996, P. 26). Reducing child mortality and specific disease rates are of significant importance to policy and achieving social, economic and environmental sustainability goals.

Environmental health factors play an important role in child survival even when controlling for socioeconomic variation (Anderson et al. 2002a). Although difficult to decipher in empirical analysis, child survival, like all population health outcomes, is clearly linked to the environment (Rainham and McDowell 2005). Children are vulnerable in the pre and post-natal environment and depend heavily on the health of their mothers and immediate surroundings. Child survival also captures the quality of health services and the internal as well as external household environment (Briggs 1999). Rates of child survival are readily available on a global scale and thus satisfy the criteria for a good indicator of environmental health. Child mortality can occur due to social, economic as well as environmental causes, therefore, child mortality as an indicator captures many "Driving force" issues of interest, including pollution, safe food and water and soil quality (Briggs 1999). Infant mortality (aged 0 to 1) and child mortality (aged 1 to 5) are determined differently by socioeconomic as well as ecological determinants, although such variations may not be readily identified (separated) at the ecological-level when explanatory data are scarce (Balk et al. 2004) (See Chapters 5 and 6).

Infant and child mortality data by cause of death allow us to investigate specific threats to health linked to social, economic and ecological factors. Where overall child mortality aggregates all causes and thus partially confounds our understanding of why mortality is high in a particular region, mortality disaggregated by cause of death allows more precise conclusions as to the cause and effect of the determinants of child mortality (See Chapter 6).

2.6 ECOLOGICAL-LEVEL ANALYSIS

The following section introduces the level of analysis employed when using environmental health indicators and why, despite imprecision and uncertainty, exploring environmental health at the macro level is useful to identify increased risks within a particular area of interest. The environmental health relationships explored within this research are at the macro or ecological level. This level of study links aggregated environmental and health data in an attempt to maximize explanatory power of secondary data. Such studies focus on comparing groups, rather than individuals, when individual level data are missing. Goldstein (1995) defines individual-level factors as those linked to constitutional (biological) or behavioural characteristics; group-level factors include environmental and social influences. This level of analysis is likewise employed as health effects induced by exposure to degraded environmental states occur at the population, rather than the individual level (Soskolne and Boremling 2002). Both the circumstances in which people live and work are important determinants of health outcomes. Therefore, an ecological approach may not be a substitute for individual level studies yet can be an important first step in identifying potential hazards and highlight areas requiring more extensive investigation (Corvalan et al. 1996).

2.6.1 Why an ecological-level approach

Where individual-level variation cannot be accurately measured due to expense, collection difficulties, lack of direct dose-response data and/or substantial within person variability not easily measured, group averages are an alternative approach (Rothman, 1993; Morgenstern, 1995). Environmental characteristics at this level are generally outside the control of the individual in the short run. Therefore, ecological-level analysis is an appropriate level at which to explore environmental health determinants that may be linked to a group's immediate surroundings (Marmot 1998, 2002). Morgenstern (1995) notes "…where individual level studies may not be practical for estimating exposure effects if exposure varies little within the study area," ecological studies, on the other hand, are able to cover a much wider area and thus potentially reveal "substantial variation in mean exposure across groups" (p. 65).

2.6.2 Problems with ecological-level analysis

Both the method of analysis and the variables included are infinite in such studies, making the design and estimation of ecological models subject to many criticisms and interpretations and no formula for optimal model design is known (Greenland and Morgenstern 1989, Nurminen 1995, Blakely and Woodward 2000). Due to inexact linkages between exposure and outcome, "ecologic studies are subject to unique biases not present in individual-level studies" (Nurminen and Nurminen 2000). Aggregation bias (or the grouping of individuals) is the most widely sited problem associated with ecological level studies and can exaggerate the magnitude of the true association (Greenland and Morgenstern 1989, Nurminen 1995, Blakely and Woodward 2000). Nurminen and Nurminen (2000) define aggregation bias as the failure of aggregate-level association to properly reflect individual-level associations. Confounding of this kind occurs when assumptions are made about relationships across levels, that is, when effects at the group level are assumed to hold at the individual level. This is also known as the ecological fallacy. Within this study, we will make no direct inference about individuals, thus avoiding cross-level bias.

2.6.3 Data requirements for ecological-level health studies

The data used in an ecological analysis are classified by Morgenstern (1995) in three ways: aggregate, environmental or global. Aggregate measures are summaries of individuals in a group, e.g. infant mortality. The second type of variable is an environmental measure, capturing physical characteristics of a place in which a member of the group works or lives, e.g. ambient pollution. The final type of variable used in ecological-level studies is a global measure, such as population density (Morgenstern, 1995). Aggregate level data present a low cost opportunity to analyze and investigate spatial relationships as data are generally available from secondary sources. According to Nurminen and Nurminen (2000), three criteria be met when conducting an aggregate-level environmental health analysis: firstly, data must be widely available and thus the study simple and inexpensive to utilize; secondly, the data must produce statistically valid results that are credible and can provide a solid foundation from which to take action and, thirdly, the analysis must be unbiased and sensitive to variations, that is, the results should be *applicable* to individual level studies.

In order to establish a reliable link between environmental pollution and health outcomes, high-quality data are needed. Data may be in the form of routinely collected data or data specific to a research project (Corvalan et al. 1996). If exposure-response data are available, estimates of the population exposed and specific health outcomes would be more readily identifiable. Especially in developing countries, limited data reduce the possibility of estimating a dose-response function, for example. Furthermore, the impact of many pollutants on health is poorly understood. Environmental data are generally of poor quality due to limited resources. The nature of environmental pollution in the region is notoriously difficult to quantify and measure. Data limitations inherent to both environmental health studies as well as data from the developing world inarguably limit a detailed understanding of many environmental health relationships. At the same time, ecological-level health studies are not considered substitutes for individual level studies; operating rather as alternatives until improved methods and data become available (Corvalan et al. 1996, Upshur and Crighton 2004). Some have called for a two-tiered approach in looking at EHI in the CARs, and particularly in the ASB, where high quality individual level data are scarce (Upshur and Crighton 2004). Such an approach combines existing secondary data widely available (from the WHO, for example) with supplemental data collected from household level studies (such as data available from DHS). Such an approach allows greater certainty in making EHI links with data from the region where the health data are known to be underestimated, yet presents estimation problems in the form of cross-level inference.

Within an ecologic study looking at the relationship between human and environmental health, the analysis can be classified as either exploratory or analytic (Morgenstern, 1995). An exploratory approach is used when the primary exposure of interest cannot be directly measured; such cases would include the impact of lost biodiversity due to deforestation, externalities from desertification, soil erosion and land degradation. An analytic approach is used where the primary exposure variable is measured, for example, the known release of a pollutant into a local water source and the measurable incidents of an infectious disease, such as cholera, reported by those dependent on the water source. The focus of this research is not testing an isolated incident of exposure or pollutant, but rather an ongoing environmental state or a "continuum" of threats (Morgenstern, 1995). Therefore, the empirical analysis within this work is exploratory in nature. Nurminen and Nurminen (2000) support that "…a thorough investigation of environmental health effects does not necessarily require extensive analysis involving direct attribution of exposures or numbers at risk," (p.64); an informative investigation of area-specific environmental health threats can be well explored through the incorporation of existing morbidity and mortality data.

2.7 CONCLUSIONS

This chapter introduces the key concepts and assumptions applied throughout the subsequent chapters. Linking environmental impacts to health outcomes at any level is confounded by measurement and thus aetiological issues. Supported by improving scientific evidence, there is an ever-increasing awareness of the impact of anthropogenic activities on the environment and ultimately on human welfare. Efforts to ensure sustainable livelihoods in the most resource dependent economies require economic and social priorities to recognise the importance of environmental protection.

3

AGRICULTURE, THE ENVIRONMENT AND HEALTH

ABSTRACT

The economy of monoculture cotton production in the Soviet and post-Soviet period has brought about severe environmental degradation in the CARs and is as a key factor in explaining poor health in the region. The unique environmental externalities resulting from monoculture cotton production are outlined along with the pollutants and types of exposure specific to the region. The poorest, most vulnerable members of society are at an increased risk of mortality and a life-time of illness associated with worsening ecological conditions. The need for social policy to address environmental degradation to ensure a sustainable and equitable future for the most vulnerable populations is therefore addressed. The final section concludes.

3.1 INTRODUCTION

The transition economies of the former Soviet Union (fSU) provide a unique field of inquiry. They are both “transitional” and “developmental” by definition and are presently suffering from much of the economic and environmental challenges facing the world’s poorest countries.[3]

The former Soviet states have been in a continuum of intense transformation and transition, both politically and economically, over the past 15 years. The “success” of transformation varies significantly among Republics and has been more nominal than actual in some of the poorest Southern Muslim Republics in present day Central Asia (Figure 3.1).

Figure 3.1 Map of CIS and Baltic states (collectively the fSU). Source: www.ukrainepostalexpress.com

To understand the origin of many environmental policies and practices of the fSU and the Central Asian Republics (CARs), it is useful to look back to the historical context in which decisions about the environment were made during the Soviet period. Present environmental degradation in the CARs is the result of long term exploitation of the natural environment in the USSR due primarily to monoculture cotton production throughout Central Asia. The

[3] ‘Transition’ refers to movement towards a market economy (see Fischer, R. et al ‘The Transition Economies After 10 Years,’ NBER 7664, 2000); in the literature ‘developing’ country broadly refers to the poor, non-industrialised nations

economic potential of the region has been long recognised and agriculture has dominated trade and economic activity between the CARs and the Russians since the 19th century. Under the Soviet regime, traditional practices in food production and agriculture were altered to usher in a new era focused on the independent and self-sustained production of cotton. The USSR rapidly became the fourth largest producer of cotton in the world and by 1922, Stalin could already claim self-sufficiency in cotton production; by 1960 the USSR ranked 4th behind the UK, USA and Germany in production capacity and technology (Gleason 1991). In achieving such levels of production so rapidly, sustainable practices in food and livestock production were forever changed. To cultivate the monoculture, high-cash crops, millions of hectares of desert were converted into blooming fields of white gold.

Soviet central planning did not account for inherent limitations of the natural production base upon which the USSR flourished throughout most of the 20th century. The structure within which Soviet administrators addressed environmental issues was heavily influenced by Marxist-Leninist ideologies and as Ziegler (1985) notes, the root cause of disastrous Soviet environmental policy, was that "…in the Soviet Union, the most significant image of the environment is the official image…"(p. 365). Based on the pressing issues of the time, there are few references in Marx's seminal text *Das Kapital,* on environmental protection. However, Marxism as a guide to decision making does attempt to explain the consequences of man's interaction with his natural environment (Ziegler 1981). Collective farming ushered in by the Soviet regime displaced traditional, sustainable methods of farming long-established in Central Asia. Massive irrigation projects dominated the arid lands, diverting water from the Amu Darya and Syr Darya—once the main feeder rivers to the Aral Sea—for cotton production and ultimately bringing about the desiccation of the Aral Sea. Soviet central planners acknowledged economic aims must account for the "means" used in production (Ziegler 1987).

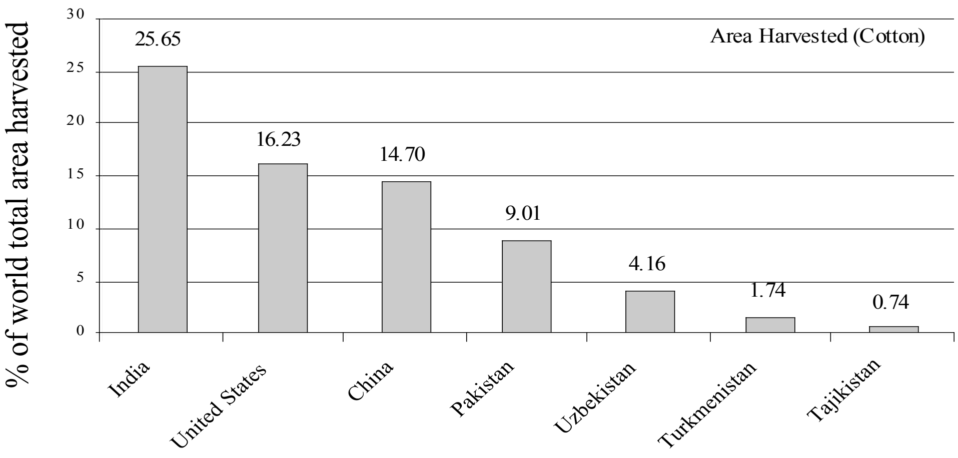
Encompassing one sixth of the world's landmass with over 8.5 million square miles of territory, fossil fuels and minerals, natural resources were seen to be in endless abundance; the advantage of having total control over production and labourers perhaps drove Soviet planners to put "significantly greater pressure" on their natural resources (Ziegler, 1985, 1987). Theoretically, centrally planned economies (CPE) should be more capable of considering and providing for general, widespread welfare of the population and environment. However, in practice, the approach to the natural resource base and the lack of regard for the finite nature of natural capital was evident throughout the USSR as it is today in the fSU and particularly in present day Central Asia. Soviet agriculture was characterised by low productivity, despite levels of land, machinery and chemical input use on a par with industrialised countries around the world (Lerman et al. 2003). After the dissolution of the USSR, the disbanded Soviet government revealed publicly that the natural environment was indeed in an alarming state. Severe air and water pollution, poor environmental health and widespread degradation of soils and forests had become commonplace (French 1991, Feshbach and Friendly 1992, Micklin 1998, Spoor 1998, Glantz 1999).

There are various characteristics of the market-based economy that can facilitate environmental control; transition to an open market economy could enable more careful control of environmental quality in the period of transition. However, environmental problems present unique obstacles to well functioning markets with political, social and economic accountability, including the construction of markets where there may be none naturally (Dasgupta, 2004). In light of poor economic, political and social accountability and openness across most of Central Asia, much economic activity, and particularly that linked to the use of natural resources, continues to be regulated by mechanisms other than a price mechanism. Therefore, the nominal movement towards an open market economy cannot alone bring about efficiency in control of environmental resources, however, there are various conditions found within the market structure under which the needs of effective environmental management could be fulfilled. Indeed, much of the mismanagement and inefficient use of natural resources in the CARs can be traced to market failure or a total absence of markets (Panayotou 1993).

3.2 AGRICULTURE IN THE CARS

Across Central Asia, varying environmental factors continue to shape and influence health outcomes (Schrad 2006). Of principal concern in this chapter, however, are negative externalities resulting from the agricultural sector upon which the Central Asian economies are so heavily reliant. The productive capacity of the natural environment throughout the whole of the ASB has been severely affected by industrialised monoculture cotton production. Unlike in the Central and Eastern European (CEE) republics of the fSU where industrial activities relying on lignite or soft coal and the extraction and transportation of mineral resources devastated much of the environment, in the CARs the key cause of environmental degradation was the Soviet-led development of the cotton industry (French 1991, Little 1998). Where many of the polluting industries in the CEE collapsed with the dissolution of the Soviet Union, cotton production in the CARs remains a key earner in much of present day Central Asia (Libert 1995). All Soviet cotton production was concentrated in the CARs and Azerbaijan; Tajikistan, Turkmenistan and Uzbekistan are still the primary producers in the region and the latter has always been the largest producer. In 1960, cotton production in the

USSR amounted to 4.5 million metric tonnes (MMT) and by 1980 this figure had grown to nearly 9.6 MMT; by 1991, cotton production had fallen to 7.8 MMT. A reduction in cotton production in the post-Soviet period has been the result of multiple factors, including diversification away from cotton towards self-sufficiency in wheat production, an overall decline in available chemical inputs and mounting environmental stress (Spoor, 1998). Nonetheless, cotton production continues to dominate agricultural output in much of the CARs. For 2005-2006, Uzbekistan and Turkmenistan are the 5th and 9th largest producers of cotton and the 2nd and 8th largest exporters, respectively. The region accounts for 7.3% of the total world production (including Azerbaijan), and 15.2% of cotton exports worldwide (Figure 3.2).



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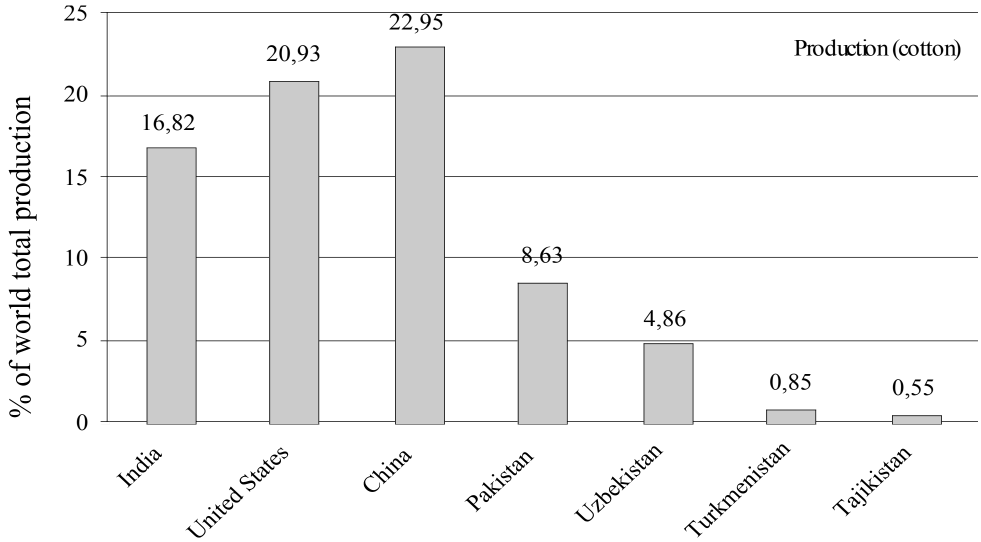

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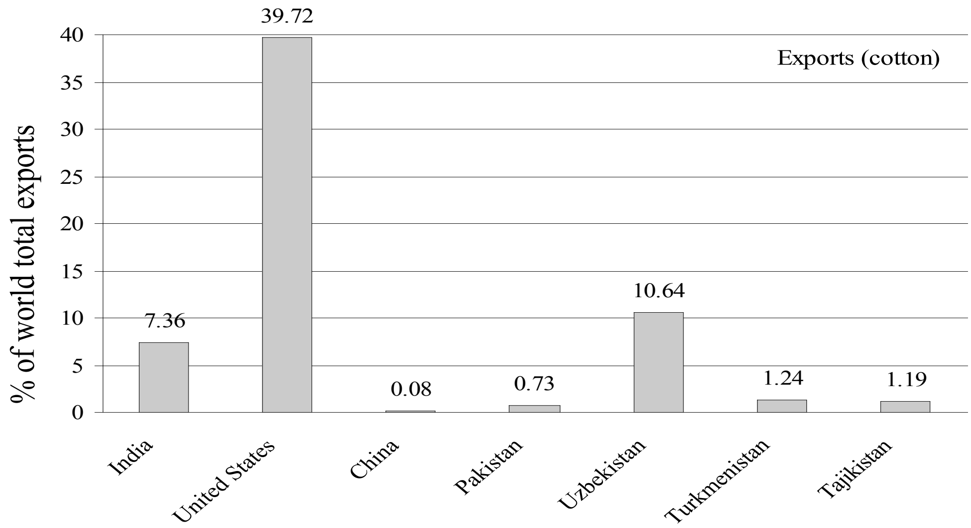


(c)

Figure 3.2 World cotton harvest (a), production (b) and export (c) as % of world total for 2005-2006. Source: usda.fas/gov/cotton

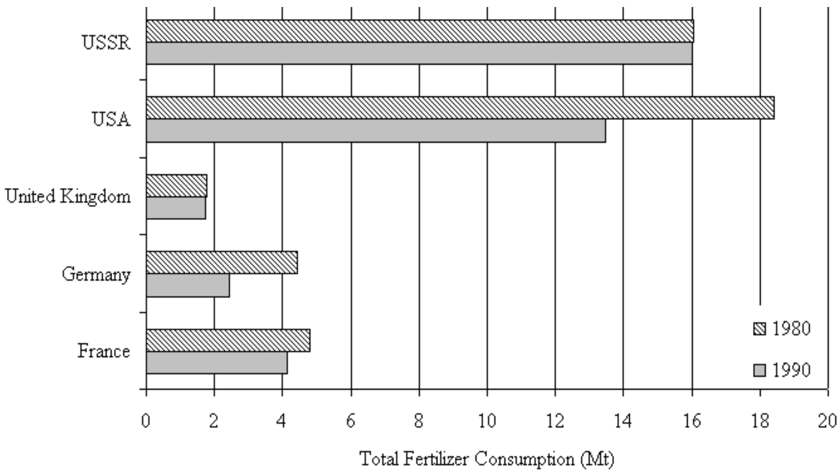
3.3 ENVIRONMENTAL EXTERNALITIES FROM COTTON MONOCULTURE

3.3.1 Chemical pollution

Globally, work in the agricultural sector is high risk and widely considered one of the most hazardous occupations (Kirkhorn and Garry 2000). The adverse health effects associated with living near or working within an agricultural area are widely cited for developed countries (Zejda et al. 1991, Daniels et al. 1997), but are comparatively poorly addressed and quantified for developing countries (Cropper 1994). One of the greatest risks to health from this industry is the use of pesticides. Pesticides include herbicides, insecticides, fungicides and other biocides (Daniels et al. 1997). Agricultural pesticides are the largest group of poisonous substances intentionally disseminated into the environment in the world (Rull and Ritz 2003). In addition to direct exposure, compounds released into the air, soil and water pollute the food chain, accumulating in foods eventually consumed by humans (Muntean et al. 2004). This line of contamination poses a significant threat to infants as compounds can be readily transferred to foetuses from mothers (Zetterstrom 2004). The chemical-intensive nature of monoculture cotton production thus poses a unique environmental health threat and specifically to rural populations and children in the region.

Cotton production utilises more pesticides than any other crop globally and despite the widespread application of chemicals, global losses from pests to the cotton industry are more than 80%, due mainly to declines in efficiency as pests develop tolerance for chemicals (Oerke 2005). Chemical applications were widespread in the USSR due to heavy subsidies from Moscow; fertilizer and pesticide use was among the highest in the world before the collapse of the Soviet Union Figure 3.3. Between 1980 and 1992, nearly 30,000 tons of pesticides were applied in the independent republic of Karakalpakstan alone, in the heart of the Aral Sea Basin (ASB) (Ataniyazova 2003).[4] This is equal to an application rate of approximately 70 kg per ha per annum, compared to an average in Uzbekistan of 55 kg, 4 kg in Russia, and a U.S. average of 1.6 kg per ha per annum during the same period. As seen in Figure 3.3, Uzbekistan still dominates the region in fertilizer consumption and accounted for over 70% of all fertilizer use in the CARs in 2002.

[4] Karakalpakstan is an independent Republic within Uzbekistan; the Karakalpaks are a minority ethnic group in the country with a distinct language, culture and history from the rest of Uzbekistan.



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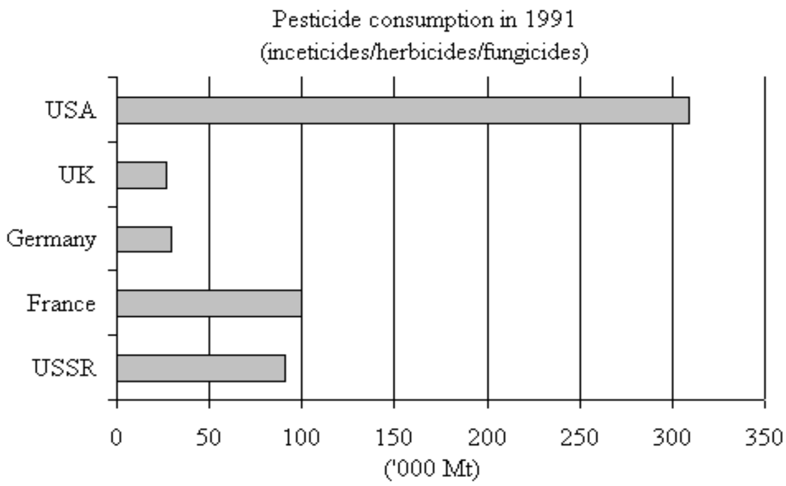

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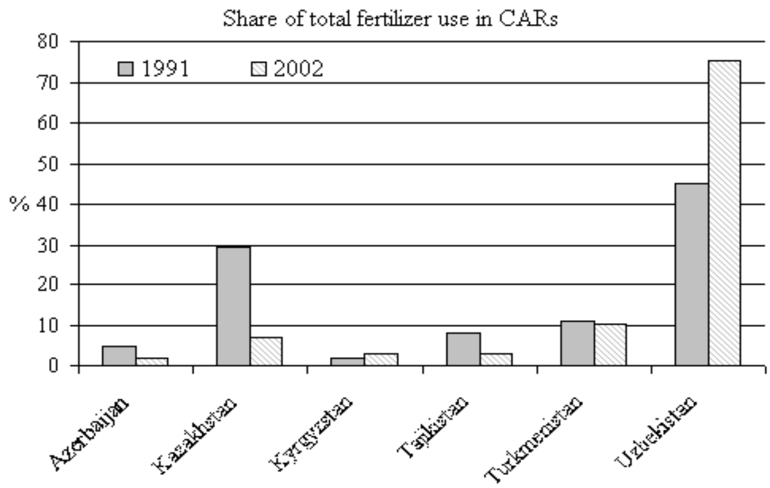


(c)

Figure 3.3 Fertilizer (a) and pesticide (b) use in the Soviet period; (c) fertilizer consumption as share of regional total consumption. Source: FAO, Cornell University (USSR DATA).

The use of some chemicals, such as DDT, was banned in the USSR, however, traces are still detected (Muntean et al. 2004). Like many such chemicals, residual concentration in the soil can last well beyond cessation of use. A study looking for heavy metals and pesticides and other chemicals in processed cotton found 25% of Uzbek and Kazakh cotton samples contained DDT (Rybicki et al. 2004). The study identified textile samples from Uzbekistan and Kazakhstan as the only out of all samples from cotton producing regions (globally) that tested positive for residual DDT. The study found that, in fact, "(in) the majority of samples from Central Asia, the presence of some pesticides…were detected." (p. 70). The "global" content of all pesticides did not exceed more than 1ppm, an acceptable level by international standards; individual pesticides were nonetheless found in the Uzbek cotton samples in considerable excess of permissible levels (Rybicki et al. 2004). It is widely accepted that even in minute amounts, chemical concentration in the environment can have significant and long term effects in both the human and animal populations (Hayes et al. 2006). Furthermore, "average" levels of pesticide content reveal nothing about the local concentrations that can inflict devastating doses on minorities of larger populations. More than 30% of foods produced in the USSR contained pesticides well beyond standards safe for human consumption, rendering pesticide poisoning a significant cause of death, illness and injury throughout the USSR (Fedorov and Yablokov 2004). Pesticides found in treated water are still at levels far beyond those allowed by international standards, particularly in rural areas (Small et al. 2001). As seen in Figure 3.4, residual chemicals found in children nearest the Aral Sea far exceed rates in areas both within and without the region.

The most widely recognized health effects of pesticide exposure include illnesses of the central nervous system and acute pulmonary disorders (Kirkhorn and Garry 2000). Farmers in the United States are found to have higher rates of cancer of the lymphatic, brain and stomach, for example, than the rest of the population—cancers that are more highly linked to occupational hazards specific to substances used in agricultural production (Blair and Zahm 1995). The adverse effects of pesticide exposure on farm workers and their families include chronic health problems such as respiratory illnesses, cancer, neurological disorders and birth defects (McCauley et al. 2006). A review of the literature looking at the association between pesticides and the risk of childhood cancers in the US between 1970 and 1996 found leukaemia and brain cancer to be higher among those children exposed to pesticides in early childhood (Daniels et al. 1997). Pesticide exposure has been found to increase respiratory and systemic illnesses in developing countries alike, particularly among children who are considered to be the most vulnerable group in rural areas (Tchounwou et al. 2002, Salameh et al. 2003). The heavy application of pesticides for cotton production in the CARs over a 30 year period has therefore had a significant and adverse effect on the population, with women and children at greatest risk (Muntean et al. 2004). Toxic chemicals have been found at very high levels in blood and breast milk in the region and are known to be residuals of Russian-made pesticides used on cotton fields in preceding decades (Jensen et al. 1997, Whish-Wilson 2002).

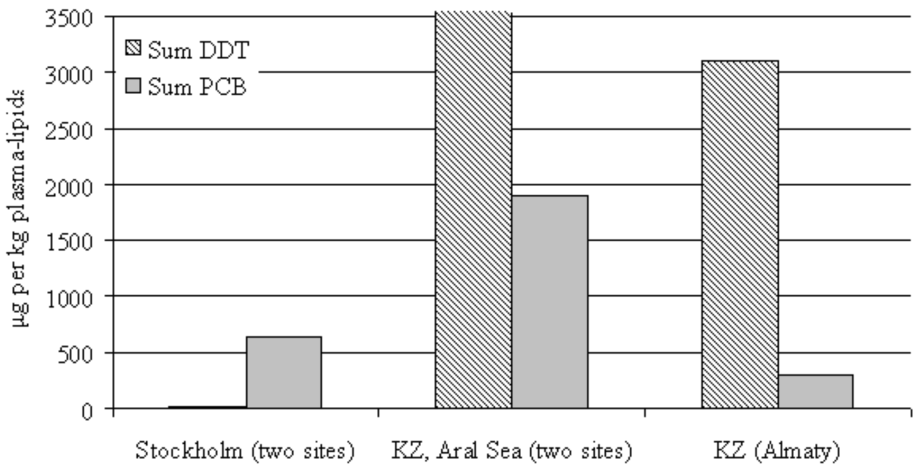


Figure 3.4 Chemical concentration in blood plasma in the ASB and Sweden. Source: Jensen et al, 1997

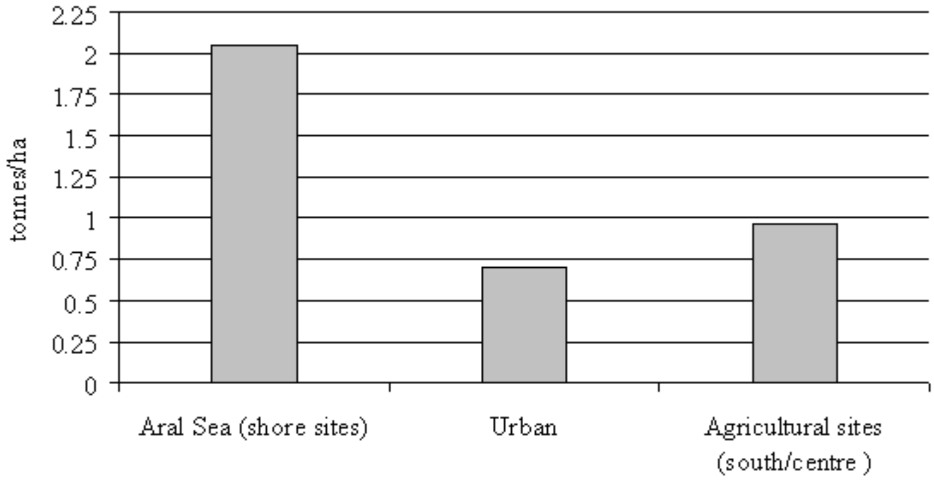
Quantifying and valuing negative health externalities resulting from exposure to pesticides and related illnesses is problematic. Particularly in the literature on developing and transition economies, concrete evidence of costs for policy recommendations (e.g. benefits transfer) is limited (Cropper, 1994). In a seminal paper by Pingali et al. (1994), the health costs associated with pesticide use were found to exceed potential benefits (e.g. combating pests and diseases that devastate crops). The authors' used a cost of illness (COI) approach to estimate loss from exposure in terms of morbidity and mortality in the Philippines. Their findings, however, are not readily transferred across countries due to variation in data quality and availability. Cropper (1994) proposed banning, restricting or taxing pesticide use where the marginal social cost of pesticide use in the form of morbidity and/or mortality exceeds benefits of pesticide use. To conduct similar estimations in the CARs as used by Pingali et al. (1994), application rates at the regional level and detailed morbidity, mortality and exposure data would be required and are not available to the public (Upshur and Crighton 2004). General COI studies are limited mostly to developed countries and a benefits-cost/transfer approach is problematic for such analysis due to significant cultural, behavioural, institutional as well as significant environmental differences between countries (Alberini and Krupnick 2000). Furthermore, pesticide use in the CARs is highest among cotton growing regions. Cotton is a principal earner in the region and the health benefits assured under reduced pesticide application in this setting are discounted at a much higher rate than health and (direct and indirect) economic and environmental costs associated with their use. The International Crisis Group (ICG), an active non-governmental organisation (NGO) in the region recently published a substantive and disturbing report on the negative social, economic and environmental impacts of monoculture cotton in the region. The group reported "the economics of Central Asian cotton are simple and exploitative…the considerable profits go either to the state or small elites with powerful political ties," while costs to health are borne by local populations (ICG, 2005, p.1) As a result, there is a lack of evidence that effort at the national level has been made to estimate the value of avoiding illness in Central Asia linked to externalities from the agro-industry. Additionally, the economic impacts of health costs (in particular non-communicable diseases) is distinctly absent from the literature and especially for developing countries (Abegunde and Stanciole 2006).

3.3.2 Air pollution

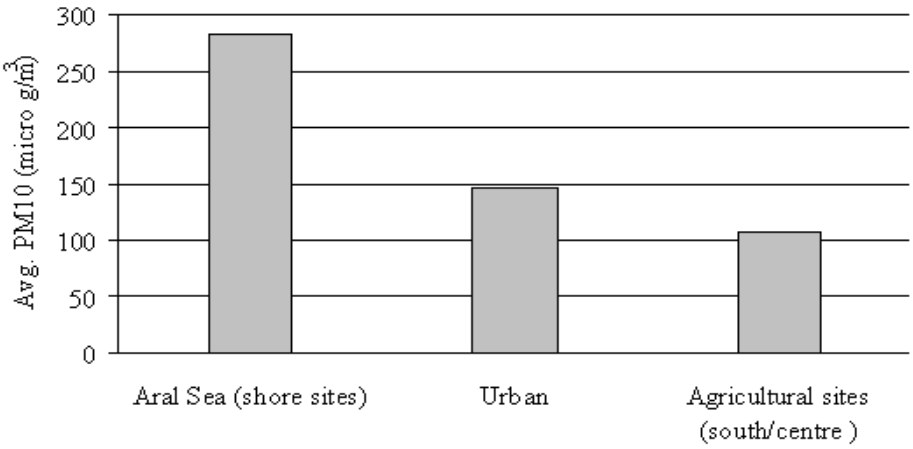
While urban air pollution is predominately from chemical and metallurgical industries, automobile emissions and the burning of fossil fuels, rural regions suffer from a unique form of air pollution resulting from the agricultural sector (Tokacheva, 2004). Rural air pollution in Central Asia is notably different from pollution characteristic of other emerging economies and has caused widespread respiratory illnesses and diseases of the respiratory tract (Ballance and Pant 2003). Air contamination from the agricultural sector is primarily from two sources: airborne substances from grain and cotton dust and its constituents (Zejda et al. 1991); and dust storms from widespread desertification (Lal 2001, Wiggs and O'Hara 2003, Griffin and Kellogg 2004). Arid soil is a key contributor to dust in the atmosphere and with desertification rates accelerating around the globe, the quantity of dust in the Earth's atmosphere continues to rise (Lal 2001 and Griffin et al., 2004). Respiratory conditions from the agricultural sector may be the result of multiple-exposure risks and can be mistaken for common viral and/or bacterial respiratory infections, making detection and specification of risks problematic, even in a developed context where diagnoses are more readily available and complete (Kirkhorn and Garry 2000).

Complicating the measurement and assessment of such pollutants is the type of dust found in the region; the soil is very fine and can be transported great distances. Also limiting estimation of the health impact of particulate matter in the ASB is the lack of health-relevant indicators measuring air pollution over a sufficient area and period, such as PM_{10} and $PM_{2.5,}$ for which widely available dose-response curves have been calculated to estimate the relationship to mortality (Ballance and Pant 2003). In a study conducted by Wiggs et al.

(2003), dust deposition rates in an area nearest the Aral Sea were found to be significantly higher than other urban and agricultural areas in close proximity to the Sea (Figure 3.5)



(a)



(b)

Figure 3.5 Variation in dust deposition (a) and PM_{10} concentrations (b) in 3 separate sites in Karakalpakstan between May-Oct, 2000 (averaged by site for the period). Source: Wiggs, et. al, 2003.

3.3.3 Water quantity and quality

The majority of surface waters are located within the ASB where the Syr Darya and Amu Darya rivers are located—once the main tributaries to the Aral Sea. There is widespread pollution of ground water from chemical run-off in the application process and, as a consequence, poor water quality and quantity pose one of the greatest environmental health threats to rural populations as irrigated agriculture holds priority in water consumption over industry use and domestic needs (Semenza et al. 1998, Buckley 2003).

Worldwide, more than seventy percent of all fresh water is used for agriculture. Per capita water consumption in Turkmenistan and Uzbekistan, the largest cotton producers of the CARs, is amongst the highest in the world (Pearce 2006). Significant variation between the fSU republics exists in per capita usage, with Lithuania at the low end of the spectrum (70m^3/year) and Turkmenistan with the highest withdrawals (5700m^3/year). The world average of per capita withdrawals is 560m^3/year (FAO 2006). Per capita water withdrawals are on average 30-times higher in the CARs than in the Baltic States; 90% of all withdrawals are used for agriculture, amounting to the highest share of water use for this sector in the world (FAO 2006). Despite such excessive withdrawals, potable water is in extremely short supply for the growing, rural population in the CARs.

The southern, larger Aral Sea (LAS) no longer receives water from the Amu Darya, once its main feeder river, due to the extent of diverted water for upstream irrigation (Figure 3.6). In recent years, the northern Aral Sea (NAS), located on the Kazakhstan side, has started to "refill" due to an international rehabilitation effort. The Syr Darya Control and Northern Aral Sea project is estimated by the World Bank (2005) to have already benefited approximately 1 million people in the area due to the construction of a dam between the northern and southern portions of the Sea (Figure 3.7). The northern body of water is now retaining water received from the Syr Darya and the area has already begun to produce economic and social benefits from the flourishing fish stocks. No such rehabilitation effort is possible with the southern, larger portion of the Aral Sea, which is expected to fully disappear over the coming decades. There are initiatives to restore the delta wetlands and lakes in the Karakalpak region, known as the Drainage, Irrigation and Wetlands Project (World Bank, 2005). This initiative is expected to improve fish stocks and ranching, but will not exhibit benefits for another 10 years. It is the exploitation of water, therefore, not a shortage, which is a primary cause of environmental degradation in the ASB (Sievers 2003).

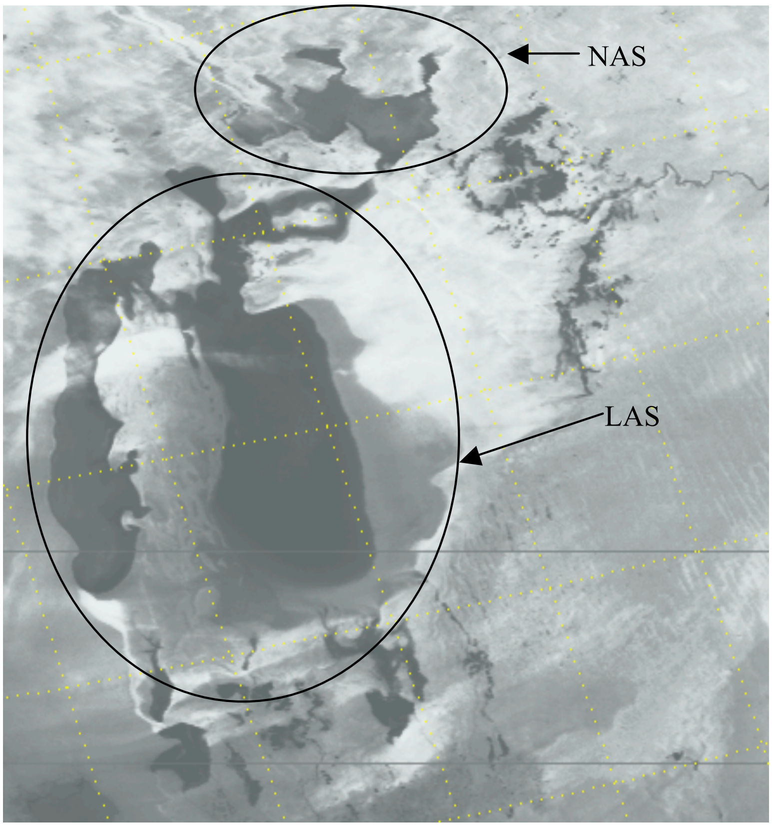


Figure 3.6 Larger Aral Sea (LAS) and Northern Aral Sea (NAS) in March, 2004. Source: NASA

Figure 3.7 The dam constructed under the Syr Darya Control and Northern Aral Sea project. Source: World Bank, 2005, www.worldbank.org

3.4 LINKING AGRICULTURE, THE ENVIRONMENT AND HEALTH OUTCOMES

Investigating the negative environmental externalities and consequential health effects associated with agricultural activity in the CARs leads to a greater understanding of the complex and volatile connection between man and his environment and the many economic costs associated with unsustainable activities. While the literature is rich in the environmental consequences of agricultural activities in this region, as well as the economic losses associated with unsustainable irrigation activities and monoculture cropping, less has been written about the human health costs associated with extensive environmental damage from unsustainable agricultural practices (Anderson1 1997; Saiko and Zonn, 2000; Franz and FitzRoy 2006b). The current system of cotton production is unsustainable in a reformed economy, thus perpetuating a stagnant economy in the transition period and prohibiting much needed reform (ICG, 2005).

As introduced in Chapter 2, environmental pollution negatively affects health, but the share of mortality or morbidity attributable to pollution is difficult to measure, thus preventing much action and discussion on such hazards (Little 1998, Prüss et al. 2002, Briggs 2003). Poor data quality and availability precludes the precise attribution of pollution to health outcomes, thus making the link between mortality, morbidity and local environmental degradation imprecise. True rates of mortality and morbidity are therefore uncertain but surely much higher than official rates, as supported by household surveys.[5] The precise distribution of causes of morbidity and mortality also remain unclear, nonetheless, the group most adversely impacted by environmental pollution in the CARs is the rural poor and such disadvantaged populations often experience greater exposure to environmental hazards.[6] Millions of rural poor are exploited in the production of cotton, keeping costs artificially low. The social and environmental externalities are widespread and unaccounted for in the production process, rendering cotton production profitable in the short-run for the Central Asian governments (ICG, 2005).

The political economy is important with regard to informed decision making on resource consumption and sustainable production (Dasgupta 2004). Particularly in the transition economies of Central Asia, political guidance must be the impetus to environmental improvements and agricultural reform. Due in large part to high reliance on the agricultural sector, in the post-Soviet period, Sievers (2003) argues:

[5] Refer to Measure DHS (Demographic and Health Surveys) from which household-level surveys are available for Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan

[6] For discussion see P. Brown, 'Race, class, and environmental health: a review and systematization of the literature', *Environmental Research,* Vol 69 No 1 (1995) 15-30

"...the (CARs) made modest progress in building basic institutions, little progress in building healthy economies, some progress in establishing or re-establishing non-sustainable economies, and simply no aggregate progress in ensuring environmental health" (p. 158).

Dependence on the agricultural sector as a primary source of employment and foreign exchange earnings (to a lesser extent in Kazakhstan) has differentiated the CARs from the other fSU republics in the post-Soviet period. Ongoing dependence on this sector has largely defined and dictated economic performance since 1991, restricting movement towards economic policies that incorporate sustainable development goals (Lerman 1998, Goletti and Chabot 2000). In Uzbekistan, for example, the agricultural sector has to a great degree softened the impact of severe socioeconomic crises in the transition period (Kandiyoti 2003). Nonetheless, current economic growth—dependent on earnings from this sector—ultimately fuels poverty through unsustainable resource consumption, impacting most heavily on the rural poor.

Long term economic and social stability is even less probable now than at the time of collapse of the Soviet Union (Sievers, 2003). For example, in line with the UN Millennium Development Goals (MDGs), Uzbekistan published a National Environmental Health Action Plan (NEHAP) in 1999 highlighting among other things the wasteful and harmful nature of cotton production, particularly the danger to human health through contaminated food (Olimjonov 1999). Apart from identifying the many environmental, economic and social problems resulting from this sector, realistic, concrete proposals for changing the source of this problem were absent, e.g., the development of alternative markets. In the NEHAP, it was reported cotton production had been reduced to an "ecologically sustainable" level in the post-Soviet period—although there is no empirical support for this claim nor is it qualified with what is defined as "sustainable." Furthermore, the NEHAP did not address the widespread de-mechanisation of cotton production in the post-Soviet period (particularly in Uzbekistan) and the obligatory participation in cotton harvesting by children and school-aged pupils as a result, thus increasing population exposure to harmful externalities associated with its production (Pomfret 2000, ICG 2005). Further impeding international pressure to address public health concerns in the region is that each republic has its own proposed health care reform process, the implementation and success of which varies among republics and is poorly understood outside each country (McKee and Chenet 2002). Therefore, gains in environmental protection from emission reductions and reduced chemical applications in the agricultural sector are a consequence of economic slowdown and are not sufficient to ensure a sustainable future.

Collectively, the CARs have signed up to a number of intra-regional and international treaties and agreements indicating their ambitions to improve human and environmental health by achieving minimum international health and environmental standards, such as ICAS and IFAS to address the Aral Sea crisis, the IWCW to improve water sharing and usage, and the UNCCD to combat desertification (Biliouri 2000).[7] Despite such initiatives, economic reliance on the agricultural sector in its current form continues to exploit limited resources, promotes the uneven distribution of water, exacerbates desertification and ultimately continues to degrade the fragile environment in Central Asia. At the same time, reported economic growth in recent years ignores the source of this growth, namely unsustainable agricultural practices, and continued lack of opportunity for the poorest populations who are also the most widely exposed to environmental degradation. Cotton is still perceived as the "engine of economic growth" in the region and especially by national governments.[8]

At present, there is not a single proposal for aggregate, "non-ambiguous" reform to promote true environmental sustainability in the CARs and a distinct lack of evidence that the impact of environmental factors on health is considered in policy-making. As a consequence, the link between environmental degradation and the impact on human health continues to remain outside popular and political discourse in the post-Soviet era. Long term social and economic reliance on the cotton industry, combined with Tajikistan, Uzbekistan and Turkmenistan having among the world's most oppressive governments, all inhibit the role of outside, international effort promoting much needed reform of the cotton industry and thus social and environmental improvement (ICG 2005). Future policies aimed at environmental sustainability and socioeconomic changes to promote health and well-being cannot ignore the key contributor to social and environmental instability: namely, ongoing cotton monoculture and the environment. However, short term gains in health and environmental quality are less visible than earnings from the main economic earner and thus these issues remain at the margins of policy-making in the most cotton-dependent countries in the region.

[7.] Interstate Council for the Aral Sea Basin problems (ICAS) in charge of implementing an agreement to ensure water arrived at the Aral Sea; and the International Fund for the Aral Sea (IFAS) which was set up to fund the project. The Interstate Coordinating Water Commission (ICWC) was established in 1992 to look at the division of water between states; ironically the Commission does not have representation from agricultural or industrial consumers—the primary users of the region's water resources. See the Crisis Group, Central Asia: Water and Conflict, Asia Report 34, 30 May 2002; United Nations Convention to Combat Desertification (UNCCD); The five Republics are ratified members of the treaty. See www.unccd.int for more information

[8] See www.icac.org: see "International conference: cotton: the engine of economic growth" (2002) and Cotton and Textiles – Important Factor of Economic Growth in Central Asia, 2005

3.5 CONCLUSIONS

Economic policies in the post-Soviet period have continued to place short term gains from cotton revenue above worsening environmental degradation and declining health in the CARs. Rural populations are at increased risk from such ecological threats and while improving access to high-quality health care may to some extent mitigate this risk and help to reduce widespread morbidity and mortality among the disadvantaged rural poor, social policies ignoring the environmental component to poor health will fall short of long term improvements and achieving sustainable levels of health. In the absence of reliable, detailed data on health and environmental degradation, measuring the impact of environmental externalities from this sector remain problematic. There is wide-spread evidence that severe environmental degradation in the region is playing a significant role in reduced well-being in the CARs, alongside social and economic factors.

The link between environmental degradation and human health has been largely ignored, firstly by Moscow and now by the governments of Central Asia. Disadvantaged populations are marginalised in policy-making due to poor representation at the government level. Rural populations in the CARs are at a double risk of being the largest, poorest share of the population in these republics, as well as being exposed to particularly high levels of environmental degradation due to the nature and history of the agricultural sector. The environment and agricultural sector are interlinked and decisions at the national level will affect both. At the same time, policies to promote health and social welfare will have to incorporate both elements in any effective promotion of improved health, considering the significant social and economic implications of this sector. Agricultural policies in the post-Soviet period, therefore, should be aimed at diversification away from cotton (and rice) production and towards water conservation to alleviate present environmental destruction by improving existing irrigation facilities, for example, rather than attempting to meet pre-determined quotas in the face of such high external costs.

Fundamental to sustainable and equitable development is a greater understanding on the relationship between unsustainable environmental quality and human health and more empirical investigation into trade-offs between the two. By developing a greater understanding between agricultural production and environmental quality, increased economic gains by means of improved productivity can coincide with environmental protection and thus a reduction in poverty and movement towards sustained economic growth. Finally, the poorest populations in and around the ASB reveal poor self-perceived health—a good predictor of morbidity and mortality (Crighton et al. 2003). The poor are the least able to protect themselves from environmental degradation and residents of highly degraded areas perceive their health to be adversely impacted by environmental contamination due primarily to economic activities seen to benefit only the government. Poor self-perceived health exacerbates environmental threats to health by encouraging unhealthy and high-risk behaviour among local populations who believe exposure to the surrounding environment offers them poor prospects for the future.[9] Such increased high risk behaviour may include excessive alcohol consumption and cigarette use, and poses an additional concern for public health and the long term economic and social costs associated with such behaviour (McMichael 2000, Stillman 2003); such behaviour is increasingly explored in the literature in relation to the countries of the former Soviet Union and Eastern Europe (Cockerham 1997, Grjibovski 2004). Therefore, any policies to promote economic stability in the CARs must not only consider access to health care services, but also the quality and state of the environment, efficiency and sustainability of the agricultural economy and the link to health and well-being in the region, as the poor are the least able to protect themselves from environmental degradation.

[9] Personal discussion with Asst Professor Cynthia Buckley (University of Texas, Austin) at the Central Asian Society Annual Conference, September, 2006, Ann Arbor, Michigan, on various aspects of current public health crises in the ASB

4

EXPLAINING DIFFERENTIALS IN CHILD MORTALITY IN THE CARS

ABSTRACT

This chapter establishes the role of environmental degradation as an explanatory variable for the increased probability of child deaths in the Central Asian Republics (CARs). Despite relative homogeneity during the Soviet period with respect to social and economic conditions (important determinants of child survival), both general and rural child mortality in the CARs have long exceeded rates in other former Soviet Union (fSU) republics and the differential has continued to increase with the worsening economic and ecological situation in the post-Soviet period. Official statistics reporting declining child mortality are seriously biased due to inadequate reporting in the worst affected rural areas; rates that are contradicted by household epidemiological studies. Traditional explanations of child mortality with respect to the CARs have overlooked the role of ecological degradation in explaining differentials in rates, both in the Soviet and post-Soviet period. This chapter, therefore, intends to fill the gap in putting forward the environment as an important determinant of child survival in the CARs.

4.1 INTRODUCTION

Child mortality is a widely accepted indicator of social well-being. As a concept, "well-being" signifies an overall quality of life. Personal preferences vary across individuals, societies and over time, however, the basic features of well-being do not change significantly (Dasgupta 2004). A key determinant of well-being is health. Arguably, it could be the most important "constituent" of well-being as all other components, including happiness and freedom, are at their core dependent on an individual's health status.[10] The health of the individual (and one's ability to survive) is in turn largely dependent on the social and natural environment in which one lives. The environment (within and without the household) will ultimately determine both quality and quantity of life. Investigating well-being in a society and in trying to measure its many determinants and constituents, rates and causes of mortality are important measures of welfare. Child mortality is accepted as a key indicator of social progress and economic development, revealing a society's overall ability and willingness to care for its most at-risk members (Waldmann 1992, Eberstadt 1995, Sen 1998, WHO 1999).[11] By international standards, an infant death is defined as the death of a child less than 1 year of age and the infant mortality rate (IMR) is a measure of deaths of infants aged 0-1 per 1,000 live births. Under-5 mortality (U5MORT) refers to deaths between age 0 and 5 and is likewise measured per 1,000 live births. Proximate determinants linked to the mother (e.g. health, education) are generally more important to infant survival (aged 0 to 1), whereas external geographic and environmental factors act more strongly on children (age 1 to 5) as they have more extensive exposure to the outside environment (Balk et al. 2004).

The twentieth century generally saw decreasing child mortality and thus improved life expectancy at birth. One of the Millennium Development Goals (MDGs) established at the United Nations Millennium Summit in 2000 was a reduction in child mortality. How to achieve reductions is less widely agreed upon and implementing policies to reduce mortality rates is confounded by within-and between-country variation in everything from geographic to cultural and socioeconomic determinants. Environmental degradation impacts on child survival around the world and is considered one of the primary determinants of a child's likelihood of surviving (Sen 1998, Anderson et al. 2002a). Socioeconomic factors, e.g. high levels of poverty, can lead to resource degradation. Mortality is often a function of institutional failure which promotes resource degradation and in turn, poverty, ultimately

[10] Dasgupta (2004) establishes there are two methods of measuring well-being, by looking at its 'constituents' which can include health, happiness and freedom and at its 'determinants', which are inputs such as food, clothing and water (p. 14).
[11] Infant and under-5 mortality will be collectively referred to as child mortality throughout this chapter.

resulting in ill health and often death (Dasgupta 2004). Environmental health is thus a prerequisite for well-being and a necessary component for child survival. Poverty is another key measure of well-being, however, it is a more problematic measure of relative welfare within and between countries as it depends on an arbitrary measurement of poverty and eliminates readily made cross-regional or cross-country comparisons (Pomfret 2004). In using child mortality, therefore, although its determinants may vary significantly, absolute rates offer a point of relative comparison within and between countries.

4.2 CHILD MORTALITY IN THE CARS

With its population of nearly 300 million people and a land area stretching from Eastern Europe to the Far East, studying the fSU as a collective whole explains little of the actual health differentials in the region and/or cause of death (Mezentseva and Rimachevskaya 1990). The CARs alone include over 1.5 million square kilometres and run from the Caspian Sea in the west, to the border of China in the east, and from Russia in the north to the Indian subcontinent in the south, evidencing the significant variation in everything from natural environment to socioeconomic conditions. In trying to explain causes of death in the USSR, therefore, it is inaccurate to speak of homogenous "Soviet'" mortality (Blum and Monnier 1989). Within the CARs, health policies and outcomes vary so significantly that there are almost equal dangers in referring to "Central Asian" policy or health. This pronounced variation within the CARs limits our ability to identify cause and effect of certain health outcomes, particularly those linked to the environment.

In the CARS, regional differentials in child mortality have increased since the collapse of the Soviet Union (Table 4.1). Official and household survey data indicate overall child mortality has declined during the same period, however, the magnitude of reduced rates varies significantly between sources. There exists a wide-ranging discussion on real rates of child mortality in the fSU and CARs, inter-country differentials and the effects of the transition period (Falkingham 2002, Aleshina and Redmond 2003). There is strong evidence for serious underreporting at the national level of official rates of mortality in the post-Soviet period, particularly in rural areas, accompanied by real increases in mortality.[12] Official data

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[12.] For a comprehensive review n the literature refer to B. Anderson, B. Silver, 'Infant Mortality in the Soviet Union: Regional Differences and Measurement Issues', *Population and Development Review,* Vol 12 No 4, (1986) 705-726; B. Anderson, B. Silver, 'The Changing Shape of Soviet Mortality, 1958-1985: An Evaluation of Old and New Evidence', *Population Studies,* Vol 43 No 2 1989) 243-265; Blum and Monnier (1989); E. Jones, F. Grupp, 'Infant Mortality Trends in the Soviet Union', *Population and Development Review,* Vol 9 No 2 (1983) 213-246; V. Velkoff, J. Miller, 'Trends and differentials in infant mortality in the Soviet Union, 1970-90: How much is due to misreporting', *Population Studies,* Vol 49 No 2 (1995) 241-258 ; C. Buckley (1998), 'Rural/urban differentials in demographic processes: The Central Asian states', *Population Research and Policy Review*, Vol 17 pp. 71-89; See also evidence from house hold level surveys, DHS (2002).

show mortality rates were as much as 6-times higher in Tajikistan than in the Baltic countries in 1980. Although official data claim that mortality declined between 1990 and 2004, differentials between republics have grown, with rates in Tajikistan in 2004 nearly 10-times those recorded in Belarus; under-5 mortality in the region has likewise been consistently higher in the poorest, cotton producing republics in both the Soviet and post-Soviet period (Figure 4.1).[13] Compared with other fSU countries, mortality rates are consistently higher in the CARs, while overall income levels during the post-Soviet period, a widely accepted indicator of child survival, do not show significant divergence until recently.[14] In comparison with other countries likewise categorized by the World Bank as low-income (Uzbekistan, Tajikistan, Kyrgyzstan) and lower-middle income (Turkmenistan, Kazakhstan), the CARs have amongst the highest rates of infant and under-5 mortality (Figure 4.2)

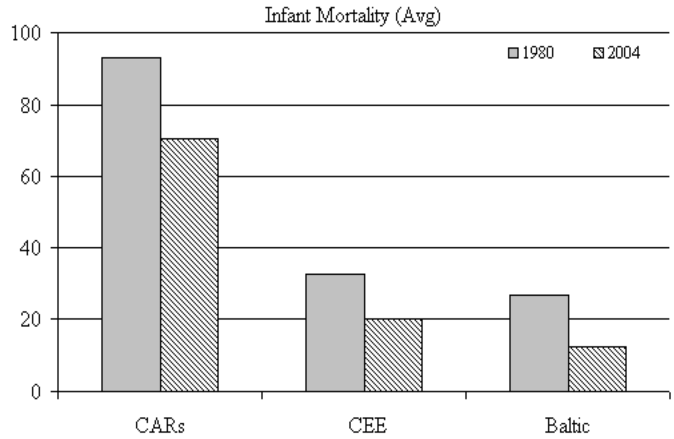
Table 4.1 Official infant and under-5 mortality rates by country

	Infant mortality rate (deaths between 0-1 per 1000 live births)					Under-5 mortality rate (deaths between 0-5 per 1000 live births)				
	1980	1990	1995	2000	2004	1980	1990	1995	2000	2004
Armenia	71	52	44	33	29	80	60	49	37	32
Azerbaijan	95	84	80	77	75	123	105	98	93	90
Belarus	21	14	15	14	9	26	17	18	17	11
Estonia	20	12	15	8	6	24	17	20	11	8
Georgia	..	43	41	41	41	*	47	45	45	45
Kazakhstan	72	53	57	63	63	85	63	67	73	73
Kyrgyzstan	90	68	63	60	58	109	80	74	70	68
Latvia	21	14	19	10	10	26	18	20	13	12
Lithuania	19	12	13	9	8	22	14	16	12	8
Moldova	41	30	29	27	23	53	37	36	33	28
Russia	28	21	18	18	17	35	21	22	21	21
Tajikistan	114	99	95	93	91	147	128	123	120	118
Turkmenistan	113	80	72	77	80	133	97	89	99	103
Ukraine	22	18	20	17	14	27	22	24	21	18
Uzbekistan	73	65	62	59	57	89	79	75	71	69
Mean	57.14	44.33	42.87	40.40	38.73	69.93	53.67	51.73	49.07	46.93
Standard Dev.	36.50	29.68	27.08	28.82	29.52	45.21	37.25	34.08	35.95	37.13
Coefficient of variation	0.64	0.67	0.63	0.71	0.76	0.65	0.69	0.66	0.73	0.79
Max	114	99	95	93	91	147	128	123	120	118
Min	19	12	13	8	6	22	14	16	11	8

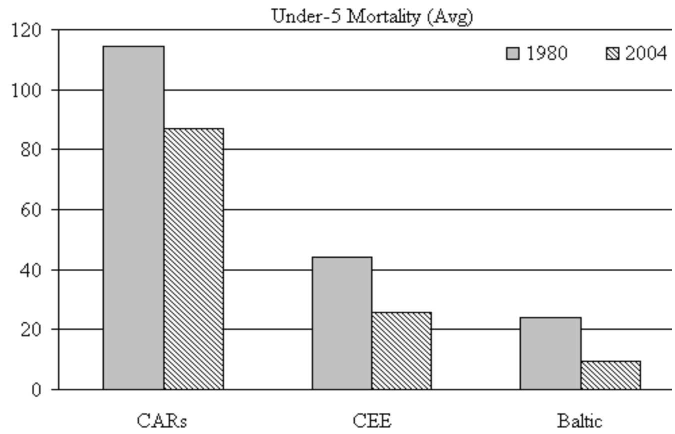
Note: *data missing; CARs are in bold. Source: World Resources Institute (WRI)

13. Proximate determinants linked to the mother (i.e. health, education) are generally more important to infant survival (aged 0 to 1) whereas external geographic and environmental factors act more strongly on children (age 1 to 4) as they have more extensive exposure to the outside environment.

14. Significant differentials in income have emerged during the same period with the Baltic States—which have out-performed other fSU Republics in most socioeconomic measures



(a)



(b)

Figure 4.1 Regional averages for infant (a) and under-5 (b) mortality. Source: World Resources Institute (WRI)

The link between varying environmental factors and the impact on child mortality has been largely ignored at the macro-level in the fSU.[15] Diseases widely linked to the external environment continue to dominate the causes of child mortality in the CARs, including anaemia, tuberculosis, kidney and liver diseases, respiratory infections and specific types of cancer, that exceed rates in other fSU republics and are amongst the highest in the developing world (McKee et al. 1998). Within the Aral Sea Basin (ASB), deaths from digestive and respiratory diseases linked to environmental contamination account for a dominant share of adult and child mortality. Although officially reported child mortality rates have declined in the post-Soviet period, differentials between republics continue to grow. This can be seen by

15. For one of the first empirical investigations into infant mortality and life expectancy differentials in the USSR see E. Carlson, M. Bernstam, 'Population and Resources Under the Socialist Economic System', *Population and Development Review*, Vol 16 (Supplement: Resources, Environment, Population: Present Knowledge, Future Options), (1990) 374-407.

the coefficient of variation in Table 4.1, going from .64 (1980) to .76 (2004) for infant and .65(1980) to .79 (2004) for under-5 mortality (where 0 is perfect homogeneity and 1 is perfect heterogeneity). Such increasing variation between republics is due in large part to a reduction in child mortality in the wealthier Baltic Republics, where economic reform, combined with maintained access to health care and increasing investment in services can be found.[16]

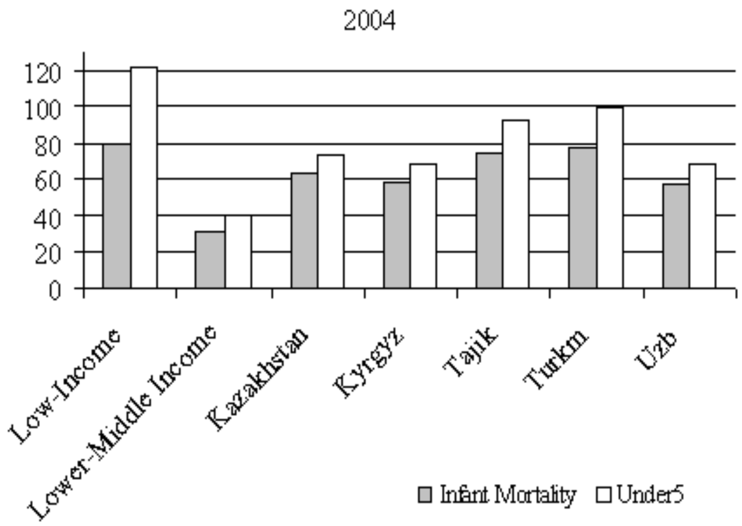


Table 4.2 Infant and under-5 rates of mortality in 2004. Source: World Bank (WB)

4.3 EXPLAINING VARIATION IN CHILD MORTALITY

4.3.1 An historical perspective

Explaining high reported child mortality rates in the region has been an issue of longstanding scholarly attention. A report of rising infant mortality in the 1970's was the beginning of a long term debate on the cause of increasing infant mortality in the USSR (Davis and Feshbach 1980). The reported increase came as a surprise to the West where it was widely believed high quality health care was universal and thus rates of infant mortality were low, along with high life expectancy. The increase was widely assumed to be a result of a failing health care system (Davis and Feshbach 1980, Velkoff and Miller 1995). The debate highlighted the importance of infant mortality as a widely accepted indicator of a society's well-being as the prospect of an overall decline in quality of life was called into question within the USSR (Eberstadt 1981).

[16] The Baltic Republics include Estonia, Latvia and Lithuania

Emerging from Davis and Feshbach's publication was a two-tier argument on what had actually caused the reported change: a real increase in infant deaths or statistical artefact resulting from improved reporting. The increase in infant mortality was in fact due to both an increase in reporting of infant deaths across the USSR, alongside higher rates of infant mortality in the poorest regions (Jones and Grupp 1983, Anderson and Silver 1986, Anderson 1989a, Blum and Monnier 1989, Velkoff and Miller 1995). Declining mortality in the European bloc was therefore shadowed by improved reporting, alongside increased rates in the poorest Republics. What the data do reveal, however, is that despite any discrepancies in reporting for infant deaths, both infant and under-5 mortality in Central Asia are higher than would be expected based on income per capita and other social indicators for the region. Combined with under-registration of deaths which renders rates even higher, the significant and sustained interest in explaining both high infant and under-5 mortality in the CARs over the years is well justified.

4.3.2 Reporting and definitional discrepancies

Official data for the CARs report improving infant and child survival in the region since the collapse of the Soviet Union. In light of reduced socioeconomic well-being, poorer access to health care, stagnant economic growth and widespread environmental degradation in the region, any real declines in child mortality are questionable (Buckley 2003). There is strong evidence of serious underreporting of morbidity and mortality in both the Soviet and post-Soviet period, particularly in rural areas, which may partially explain reported decreases (Jones and Grupp 1983, Anderson and Silver 1989a, Aleshina and Redmond 2003). In addition to definitional and reporting problems, data are unreliable due to a common practice of "massaging" that is encouraged from the top down.[17]

There is a significant difference between official and survey data colleted independently from the central governments in Central Asia. The discrepancy between official and survey data (such as that available from Measure DHS) reflects a much wider problem of poor registration of vital statistics, particularly among rural and disadvantaged populations. [18] For example, a system of charging for vital statistics registration discourages accurate and timely reporting of infant deaths thus exacerbating the problem of underreporting, particularly in the poorest republics (Kingkade and Sawyer 2001). True rates are uncertain but surely much higher than official rates as supported by household surveys. The discrepancy likewise highlights variation in the definition of a live birth used within the fSU (remnant of the Soviet

[17] Personal communication with an employee working at the department of statistics for agriculture in Uzbekistan
[18] For more information on Measure DHS (Demographic and Health Survey) survey data, methodology, available data sets, refer to http://www.measuredhs.com/aboutdhs/

period) and the internationally accepted definition established by the World Health Organisation (WHO) (Jones and Grupp 1983, Carlson and Bernstam 1990, Velkoff and Miller 1995). The main difference between Soviet and WHO definitions of a live birth is that by Soviet definition, a pregnancy ending at a gestation of less than 28 weeks *or* an infant weighing less than 1000 g *or* less than 35 centimetres in length is not considered living, unless it survives more than seven days. Therefore, only if a child survives the prenatal period (0-7 days) is it counted as a live birth (UHES 2002). Instead, by WHO standards, a live birth is defined as:

"…the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life such as heartbeat, umbilical cord pulsation, or definite movement of voluntary muscles, whether the umbilical cord has been cut or the placenta is attached. Each product of such a birth is considered live born"(WHO 2004).

Accordingly, surveys conducted by non-governmental organizations that utilise WHO definitions report rates that are significantly different from official data in the CARs (Table 4.2). For example, household surveys found infant and under-5 mortality rates can exceed government issued figures by as much as 50% in the CARs.[19] This, however, is only partially due to definitional variation and does not account for consistently large discrepancies. Only deaths during the neonatal period (first seven days of life) are affected by definitional variation.[20]

Table 4.3 Household survey vs. official data in the CARs for infant mortality

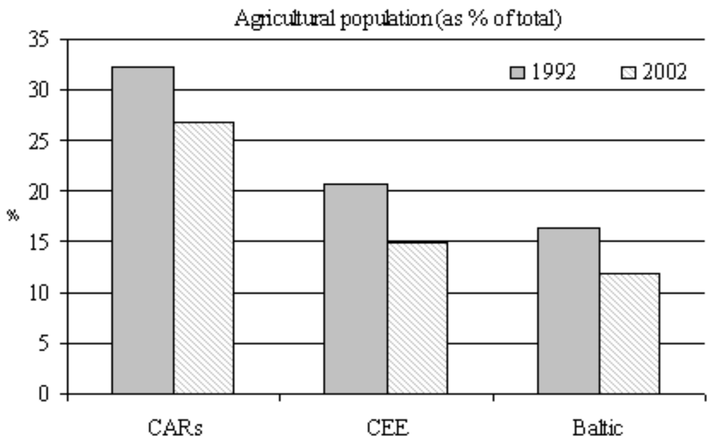
	Survey	Official	Ratio
	Uzbekistan		
1998-2002	62	19	3.23
1993-1997	64	27	2.36
1988-1992	52	38	1.39
	Kyrgyz Republic		
1992-1997	61	29	2.1
	Kazakhstan		
1992-1997	62	26	2.39
	Turkmenistan		
1992-2000	74	40	1.85

Source: Measure DHS (www.measuredhs.com)

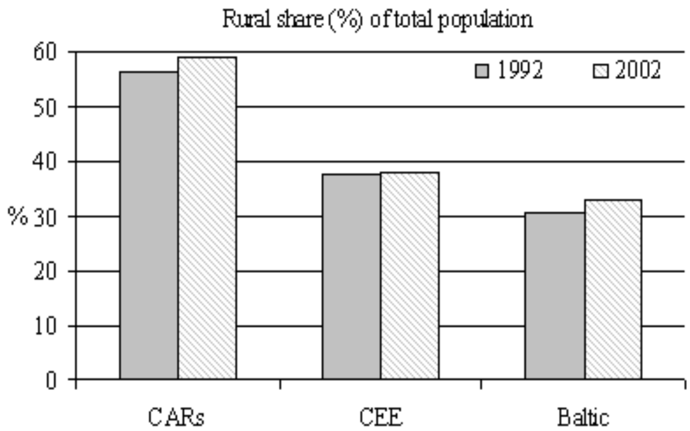
[19] Uzbekistan Demographic and Health Survey-UHES (2002); see also Kazakhstan (1999) Survey;
[20] As of 1997, all fSU republics were to have switched to the WHO definition of a live birth for reporting purposes; however, in practice the changeover has been more nominal than actual (WHO, 1999). In Tajikistan old Soviet birth registration forms are still in abundance and thus widely in use and officials stated that only once the old forms were used up, would updated forms with WHO definitions be used (personal communication with C. Buckley at the University of Texas, Austin)

4.3.3 Socioeconomic determinants

The most widely cited and explored determinants of child survival in the literature are socioeconomic factors. High child mortality rates in the CARs in the Soviet and post-Soviet periods have been viewed as a consequence of socioeconomic inequality; particularly differences in living conditions and standards between urban and rural populations (Carlson and Bernstam 1990, Buckley 1998, Falkingham 2000, 2002, Anderson and Pomfret 2003). In some rural areas, infant mortality rates are significantly higher than in urban centres, with over 100 deaths per 1000 live births (Zetterstrom 1999, Whish-Wilson 2002). Rural populations are not only the largest, poorest share of the population, with the highest share of employment in the agricultural sector in the CARs (Figure 4.3) but are at a greater disadvantage compared with rural populations in the rest of the Soviet Union when looking at rates of mortality and cause of death (Anderson and Silver 1989a) (Table 4.3 and Table 4.4). Rural child mortality exceeds not only within-republic urban rates, but rural mortality rates in other republics (Carlson and Bernstam 1990, Velkoff and Miller 1995, Buckley 1998). Respiratory illnesses among children, accidents and poisonings are consistently higher among rural populations, where cardiovascular and cancerous growths dominate in urban centres. Respiratory illnesses vary significantly between the poorest republics as well, with rates 6-times higher in Kyrgyzstan than in Georgia in 2002. However, in 1981 when Soviet policies were more homogenous between States, the incidences of death for those aged 0 to 5 from diarrhoeal diseases were nearly 180-times greater in Tajikistan (with 536 deaths per 100,000) than in Latvia, with 3 deaths per 100,000 (Figure 4.4).



(a)



(b)

Figure 4.2 Regional variation in agricultural employment (a) and share of total population classified as rural (b). Source: World Resources Institute (WRI), FAO

Table 4.4 Household urban/rural child mortality rates

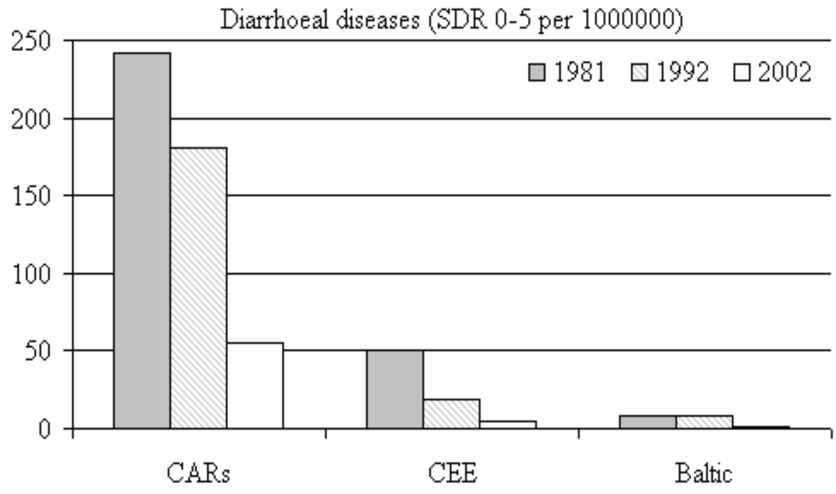
		Turkmenistan (2000)	Kyrgyzstan (1997)	Kazakhstan (1999)	Uzbekistan (2002)
IMR	Rural	80	70	64	74.6
	Urban	60	54	44	42.9
	R/U	1.33	1.30	1.46	1.74
U-5MORT	Rural	99.8	82	73	87.5
	Urban	72.7	58	50	53.4
	R/U	1.37	1.41	1.46	1.64

Source: Measure DHS (www.measuredhs.com) Uzbekistan (2002); Kyrgyz (1997); Turkmenistan (2000); Kazakhstan (1999)

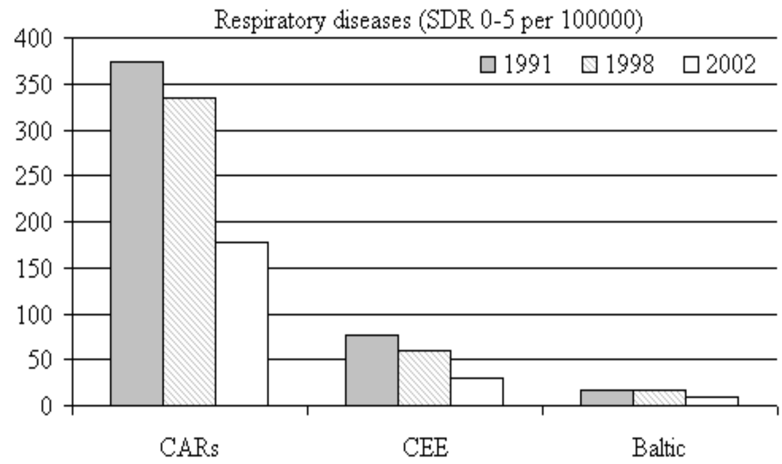
Table 4.5 Urban/Rural differentials by cause of death per 100,000 total population

1990	Infectious/Parasitic	Circulatory	Respiratory	Digestive	Accidents
Kazakhstan					
Urban	47	1340.9	190.2	80.7	259.3
Rural	55.3	1168	279.2	83.5	206.7
R/U	1.18	0.87	1.47	1.03	0.80
Kyrgyzstan					
Urban	2415.8	1184.5	234.6	84.7	275.6
Rural	2344.6	1080.8	417.1	112.3	201.4
R/U	0.97	0.91	1.78	1.33	0.73
Tajikistan					
Urban	57.8	1178.3	179.6	74.3	167.5
Rural	98.1	885.7	335.8	83.1	82.3
R/U	1.70	0.75	1.87	1.12	0.49
Turkmenistan					
Urban	95.1	1416.6	177.4	117.3	194
Rural	111.9	1429.2	319	144.8	109.4
R/U	1.18	1.01	1.80	1.23	0.56
Uzbekistan					
Urban	52.2	1312.4	185.3	102.3	180.1
Rural	68.2	1177.1	254.9	111.8	111.8
R/U	1.31	0.90	1.38	1.09	0.62

Source: Figures adapted from Buckley (1998)



(a)



(b)

Figure 4.3 Regional averages in under-5 mortality (a) and by cause of death (b). Source: WHO Health For All Data Base (HFA DB)

4.3.4 Health care

Access to health care facilities and professionals is likewise a key determinant of child survival. Reduced spending on health care in the post-Soviet period is further evidence mortality rates are not likely in decline (Table 4.5). Like most issues pertaining to present-day Central Asia, the health care systems are not well-known outside each country and variation exists between each republic with respect to the way funds are allocated and payment methods administered (Kutzin and Cashin 2002). The CARs inherited similar public health systems from the USSR, where most needs were provided for by the State; health care was widely available with even the most remote areas having basic access to treatment and facilities (Klugman et al. 2002). Although imperfect:

"There was broadly a coherent and similar system of welfare policy and provision in operation across the whole of the USSR; consist(ing) of highly subsidized prices on food, housing, transport and basic necessities, guaranteed employment, adequate health and education provision and small differentials between the wages of workers" (Deacon 2004 p. 148).

Table 4.6 Total health expenditure PPP $ per capita (1992-2002)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Azerbaijan	71.4	61.32	31.73	20.48	...	18.6	19.58	45.6	26.42	24.72	25.68
Kazakhstan	89.67	92.75	65.68	60.74	...	...	83.18	103.97	111.55	106.6	111.53
Kyrgyz Republic	94.38	...	56.5	71.44	54.1	69.44	60.24	54.03	51.51	63.25	30.78
Tajikistan	...	...	...	...	...	...	12.49	...	10.37	11.7	8.82
Turkmenistan	170	156.4	48.57	...	...	...	...	...	...	...	...
Uzbekistan	...	120.48	112.15	80.78	...	76.88	68.36	65.28	73.23	63.96	40.08

Note: (…) data are missing; Source: WHO Health For All Data Base (HFA DB)

In the 1960's, rural areas throughout the USSR suffered disproportionately large reductions in medical resources and services, with an estimated 90% of the Soviet population affected by the cuts in services (Carlson and Bernstam 1990, Velkoff and Miller 1995). Nonetheless, the whole of the USSR had rates of medical personnel per capita that exceeded most of the industrialized world and levels in the CARs were only slightly behind Russia. Access to services and investment in health care and facilities had declined before the dissolution of the Soviet Union; facilities were less well developed in hard to reach rural areas within the USSR. Decreased spending and the widespread privatisation of health services in the post-Soviet period has left a significant share of the population, particularly those in rural areas, without access to affordable health care and services that were once widely available and free (Falkingham 2002). However, despite relatively homogenous and superior socioeconomic conditions in the Soviet period, significant variations in mortality and morbidity still existed among States, with consistently higher rates found in the rural Muslim republics of Central Asia (Anderson and Silver 1989b, Anderson and Pomfret 2003, Balabanova et al. 2004).

The decline in access to health care services and facilities contributed to increased rates of child mortality reported in the 1970's throughout the USSR, in addition to improved reporting in the wealthier Baltic republics. Compared to other developing and transitional economies, as well as developed countries with significantly higher levels of per capita income, the average share of medical practitioners and facilities available per capita in the fSU has remained amongst the highest in the world in the post-Soviet period (Figure 4.5). The decline in health care provisions inarguably set the stage for poorer health in the post-Soviet period. However, such changes cannot alone address high child mortality, including high rates of disease-specific child morality that are readily linked to the environment, evidenced by the consistently high rates of mortality both before and after the collapse of the Soviet Union. Rates of infectious diseases, for example, have increased in the CARs in the post-Soviet period.

Table 4.7 Medical personnel/provisions average by region

	Hospital beds		Nurses		Physicians	
	1992	2002	1992	2002	1992	2002
CARs	9	6	916	656	340	292
CEE	7	6	958	716	394	376
Baltic	7	5	785	643	360	338

Note: Figures per 100,000. Source: WHO HFA DB

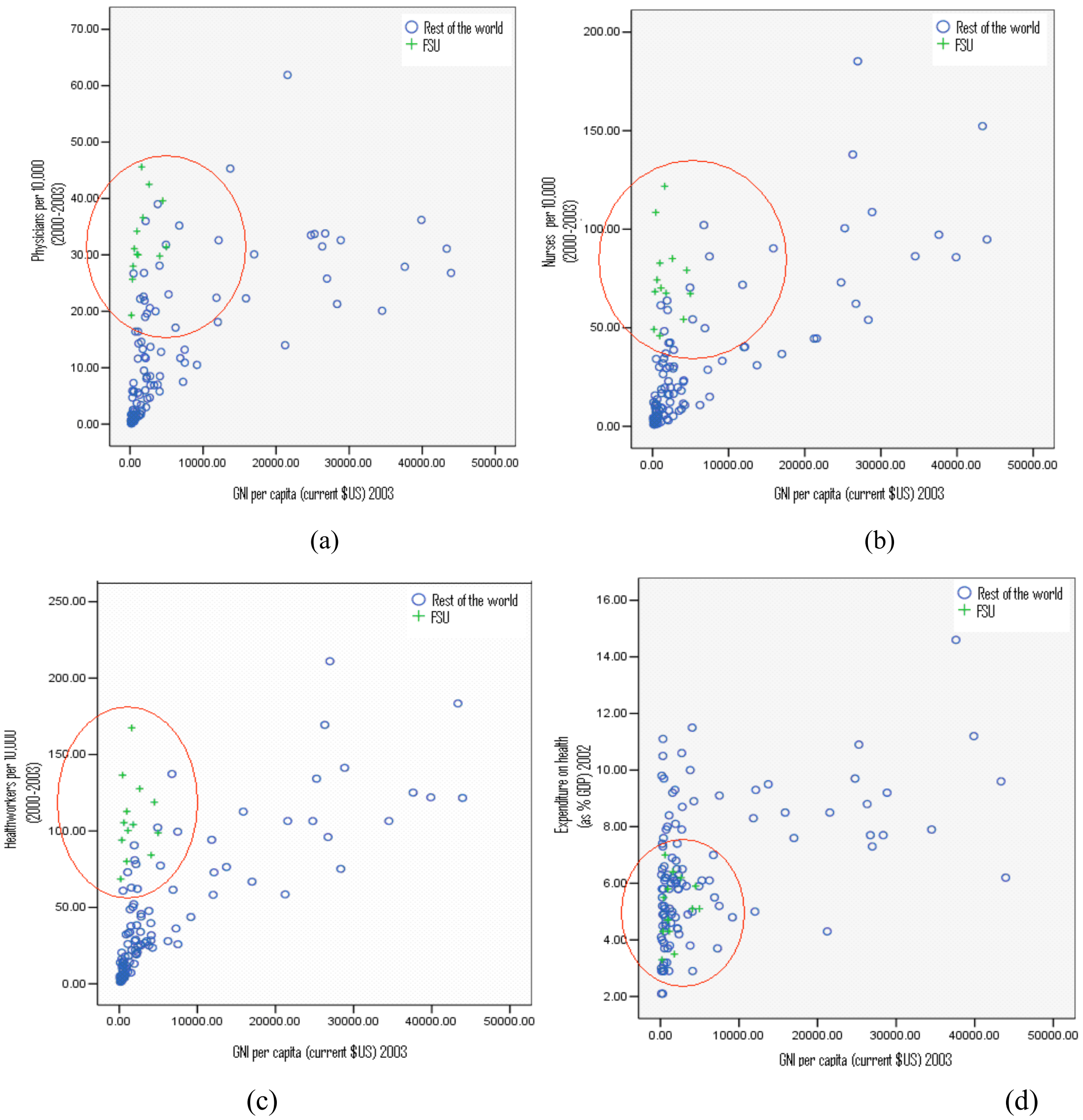


Figure 4.4 World-wide comparison of medical personnel and health care expenditure by per capita income for 115 countries plus the fSU republics. Source: WHO

4.4 ENVIRONMENT

Economic and development issues are inextricably linked to the environment and the environment plays a far greater role in the day-to-day welfare of residents in the developing world than it does those living in economically advanced countries. Children are highly susceptible to the household and external environment in which they live; they are more susceptible to the natural and manmade environment and thus less capable of surviving adverse environmental conditions than adults. When poor environmental surroundings are combined with reduced socioeconomic development and inadequate provisions of health care facilities and services, children are at an increased risk from environmental pollution

(Kamilova et al. 2004). Concern for children's health adversely affected by unsafe and unhealthy environmental conditions, including air pollution, water, sanitation and chemical contamination, has therefore gained significant interest in recent decades (Valent et al. 2004). The European Commission in 2003 recognized in their European Environment and Health Strategy that intra and inter-country variation in child mortality is poorly understood and that environmental exposure, including ambient air pollution may explain excess infant deaths (Glinianaia et al. 2004).

Immediately after independence, some attention was focused on the role of environmental pollution in explaining reduced health throughout the fSU and particularly in the CEE republics (Hertzman 1993). The general conclusion was that environmental pollution could be one of many competing causes of poor and declining health outcomes (Hertzman 1993, Little 1998). Worsening environmental conditions have severely impacted human health and well-being in the CARs, in addition to dramatic social and economic changes following independence (Ataniyazova, 2003). Environmental pollution inarguably has a negative effect on health, however, the share of mortality or morbidity "attributable" to pollution is difficult to measure; thus preventing much action and discussion on such hazards (Little 1998, Prüss et al. 2002).[21] The link between mortality, morbidity and local environmental degradation is further confounded by poor data reliability, quality and validity throughout the CARs and increasing over time as the environment deteriorates still further. The precise distribution of causes of morbidity and mortality also remain unclear, once again due to data reliability and completeness, as well as the "attribution gap" of cause and effect as environmental health relationships are not linear and only ecological data on pollution and degradation in the fSU are likely to be more severely underestimated than levels of health (Oldfield 2000, Sievers 2003). Disentangling the contributions (i.e. quantifying the effects) of each in promoting ill health, therefore, represents a significant challenge.

4.4.1 Respiratory Illness

Respiratory illnesses are a leading cause of death among children and a leading cause of population morbidity in the developing world (Kudyakov et al. 2004). Acute respiratory infections (ARIs) are the single most important cause of mortality in children under age 5, accounting for more than 2 million deaths annually (Bruce et al. 2000). An additional 2 million deaths result from general respiratory illnesses in children under age 15 (WHO 2002a). Approximately 60% of all respiratory illnesses are linked to the environment (Bruce et al. 2000, WHO 2002a). Respiratory illnesses can be communicable and non-

21. See also the UNDP Human Development Report (Oxford: Oxford University Press, 2003)

communicable in nature and represent a large category, which includes numerous bacterial and viral diseases and are defined by the International Classification of Diseases (ICD) to include acute and chronic diseases of the respiratory system (J00-J99). Particularly in the case of infectious (communicable) respiratory illnesses linked not only to increased air pollution, poor housing and high population density, but can likewise be due to other socioeconomic and demographic conditions such as a lack of breastfeeding, vitamin A deficiency and general malnutrition (Smith et al. 1999). Respiratory illness is second in the structure of overall mortality and the highest compared to all other countries in Europe, with the standard death rate for the region more than 3 times higher than the EU average (Kudyakov et al. 2004). Due to poor measurement capabilities, many incidents go unreported (Semenov and Usmanov 2002, Kamilova et al. 2004).

The role of the environment in explaining high rates of respiratory illness in the CARs is not fully understood. For example, a reverse correlation between exposure to ambient pollutants and respiratory illness among children has been observed (O'Hara et al. 2000). Other studies have found a positive correlation between pollution and an increase in children's respiratory illness (Kamilova et al. 2004). Allergies have been highly correlated with reduced ambient air quality in the CARs; allergies and asthma are known to be exacerbated by environmental contaminants linked to industry transport and agriculture (Tchounwou et al. 2002). Pesticide exposure can reduce immunity and thus a child's ability to resist respiratory illnesses when older. In remote areas of Kyrgyzstan, rural populations removed from agro-chemical pollution were less likely to develop asthma and other allergies than other rural populations in the region (Tokacheva et al. 2004).

Throughout the developing world, outdoor air pollution is usually a greater problem in urban areas resulting from transport and industry. Indoor air pollution (IAP) is primarily a threat from cooking and heating fuels used within the home with over 3 billion people relying on biomass as a main source of household energy (Ezzati and Kammen 2002). Where biofuels, wood and other agricultural materials dominate energy use in most developing, rural homes around the globe, within the CARs natural gas is the primary source of household energy (Table 4.7). Where natural gas is not readily used in rural settings, specifically in Uzbekistan and Turkmenistan, cotton stalks and husks are used for household fuel as it is a woody plant and in high supply (Yevich and Logan 2002). The use of biofuels in the CARs is low compared to most other countries at similar income levels; nonetheless, respiratory illnesses remain a leading cause of death among children and adults in the CARs.

Table 4.8 Cooking-fuel use by urban/rural population

	Kazakhstan (1999)			Turkmenistan (2000)			Uzbekistan (2002)		
Cooking fuel use (%)	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Electricity	24.2	1.8	14.3	0.5	0.4	0.5	2.1	2.4	2.3
LPG, natural gas	42	4.5	25.4	97.9	94.1	96	93.7	70.2	80.7
Biogas	29.8	50.7	39	1.3	4.9	3.1	0	0	0
firewood, straw	2.2	27.5	13.4	0	0.5	0.3	2.5	22.9	13.7
Dung	0	0	0	0	0	0	0	4.1	2.3
Other	0.5	1.1	0.8	0	0	0	1.8	0.4	1
Households surveyed	3257	2587	5844	3174	3129	6303	1863	2305	4168

Source: Measure DHS (www.measuredhs.com)

4.4.2 Anaemia

Highly saline soils, chemical concentration in land and water from agro-industrial pesticide application and poor air quality from frequent dust storms, may all be connected to and impacting directly upon child health and overall well-being in the region (Small et al. 2001, Whish-Wilson 2002, Buckley 2003, WB 2003). Widespread salinisation of soils has led to an excessively high content of salt in water and foods consumed in the Aral Sea Basin (ASB). A high level of salt consumption is a major health threat, resulting most predominately in anaemia (Ataniyazova 2003). Anaemia is a leading cause of morbidity and mortality among children in Central Asia. Anaemia can be acquired or inherited and is due to both nutritional and non-nutritional factors (Kamilova et al. 2004). Chemical exposure from pesticides and heavy metals is a leading cause of acquired anaemia and infectious illnesses are found to increase the disposition to anaemia as is maternal incidence of the disease (Kamilova et al. 2004). High salinity levels in food and water are known correlates of increased anaemia as salt binds to iron, thus inhibiting the uptake of key nutrients.

The share of ill-health attributable to each type of pollutant and threat is not readily identified. Chronic illnesses more readily indicate long term environmental degradation than infectious diseases (Small, 2001), however, both categories of illness, present great difficulty in linking human health outcomes to the environment. It is nonetheless clear the population within the CARs in general is suffering from an environmental health disaster (Whish-Wilson 2002). Some have argued communicable diseases in the region (particularly the ASB) may not necessarily be linked to the environmental disaster, including (infectious) respiratory and diarrhoeal illnesses (Small et al. 2001, Upshur and Crighton 2004). However, the incidence rate of many diseases is significantly higher in the CARs in general, and the ASB in particular, than in the rest of the fSU and higher than national averages. Respiratory conditions are plausibly linked to dust storms and air quality, but the link between infectious (and non-infectious diseases) to the environment is still uncertain due largely to poor data quality (Small et al. 2001, Wiggs and O'Hara 2003).

Endemically high rates of mortality in both the Soviet and post-Soviet period are evidence of long term variation between republics that cannot be due to socioeconomic factors alone (Franz and FitzRoy, 2006a,b). Furthermore, urban/rural differentials, including variation in access to health care, does not account for the level of child mortality in the CARs, considering the relatively high level of development afforded under the Soviet umbrella (Savas and Gedik 1999). There is no question of whether or not worsening environmental degradation has impacted upon human health and well-being, alongside dramatic social and economic changes; disentangling the contributions (i.e. quantifying the effects) of each in promoting ill health, however, still presents a significant challenge (Briggs 2003).

4.5 CONCLUSIONS

Child mortality is a leading indicator of social and economic well-being and high mortality signals poverty, reduced access to health care services and personnel, among other traditional determinants. Children are likewise particularly susceptible to negative externalities associated with environmental degradation. Exploring the link between environmental and population health outcomes is important for sustainable and equitable development. Inequality and differentials in leading demographic and socioeconomic factors have, to a great degree, overshadowed the role of the environment in explaining child mortality as such factors are more easily measured and their effects more directly linked to health outcomes. Nonetheless, the CARs are a unique subset of fSU countries where environmental degradation has been particularly severe, and the domination of the economy by monoculture agriculture presents a profound threat to rural populations. A healthy environment is a prerequisite for sustainable development, particularly in developing rural economies where populations are widely exposed to and highly dependent upon the natural environment.

The link between environmental degradation and human health may have been largely ignored, firstly by Moscow and now by the governments of Central Asia, as the disadvantaged populations are marginalised in policy making due to poor representation at the government level. Action at the oblast (administrative) level within Central Asia by national and international actors is important in informing the worst effected population of hazards linked to the environment and health outcomes which are to some extent avoidable or can be moderated with treatment. Nonetheless, while scholars, international and non-governmental organisations have been long involved in the Aral Sea crisis and the ecological externalities as a consequence of the disaster, there is limited evidence of concrete improvements at the national level. The institutionalisation of monoculture cotton and the lack of attention by elite government officials in the most intensive cotton producing republics render progress and tangible improvements in both the health, social and ecological situations of the rural poor far from being realised. Growing differentials in income and other socioeconomic factors in the CARs in the Soviet and post-Soviet period do not fully account for differentials in child mortality and particularly rural child mortality. If mortality is a function of economic and demographic variables alone, then child deaths in the Soviet period would have demonstrated much less variation between countries as socioeconomic conditions demonstrated much greater homogeneity. The data, however, show rates have been consistently higher in the CARs than in the other Soviet republics, due in part to flawed agricultural and environmental policies. Rural populations in the CARs are at a double risk of being the largest, poorest share of the population in these Republics as well as being exposed to particularly high levels of environmental degradation due to the nature and history of the agricultural sector in the region. The environment and agriculture are interlinked and decisions at the national level will affect both; at the same time, policies to promote health and social welfare will have to incorporate both elements in any effective promotion of improved health.

Differentials in rates of infant and under-5 mortality in the Soviet and post-Soviet period provide evidence that social policies alone are insufficient to reduce high mortality in the face of worsening environmental degradation. Combined with growing asymmetry in income and access to social provisions, the impact of environmental quality on health outcomes needs to receive more widespread attention in investigating high mortality rates not only in the CARs, but in natural resource dependent economies around the world, both developing and developed a like.

5

AN EMPIRICAL INVESTIGATION OF THE DETERMINANTS OF CHILD SURVIVAL

ABSTRACT

This chapter explores the determinants of child mortality in the CARs using a multivariate, cross-country approach to test the hypothesis that specific factors plausibly related to extreme environmental degradation from monoculture cotton production explain high rates of child mortality, even after controlling for a wide range of other relevant factors. In the absence of direct dose-response indicators linking mortality to environmental pollution and/or degradation, theoretically motivated socioeconomic and environmental variables are used to capture variation in child mortality among the CARs and 56 additional developing and transitional countries. Regional dummies were used to capture otherwise immeasurable spatial variation between countries that may also impact on child survival. The most widely used analytical framework in the literature for exploring the determinants of child mortality is discussed and the variables specifically explored within this study to explain "excess" child mortality are outlined. Evidence of higher mortality in the CARs likely due to environmental degradation in the region is found. The final section concludes.

5.1 INTRODUCTION

The purpose of this chapter is to explain child mortality and fertility using a multivariate cross-country approach. To do this, the following hypothesis was tested:

- In the CARs, specific factors plausibly related to extreme environmental degradation linked to monoculture cotton production help to explain high rates of infant and under-5 mortality, even after controlling for a wide range of other relevant factors.

In the absence of direct dose-response indicators linking mortality to environmental pollution and/or degradation, theoretically motivated socioeconomic and environmental quality variables, combined with regional dummies, were tested to capture variation in infant and under-5 mortality among the CARs and other countries at similar stages of economic development.

This study includes four innovations: firstly, using a fairly homogenous sample of developing countries, more omitted variable bias is controlled for than previous papers that include a mix of developing and developed countries. Secondly, endogeneity of fertility in the mortality estimation was controlled for, where fertility is a function of socioeconomic determinants. Thirdly, within and between country distribution in income was controlled for by using a consumption indicator for the poorest share of the population as well as an index of income inequality. Finally, motivated by the extreme regional environmental degradation and known effects on health outcomes, dummies were utilised to capture excess mortality in the CARs that is not explained by the exogenous socioeconomic and environmental variables (as well as specific problems in other regions such as sub-Saharan Africa).

5.2 BACKGROUND

Endogenous maternal and demographic factors impact most directly on an infant's chance of survival, while socioeconomic factors play a greater role in the survival of children over age one (Balk et al. 2004). Socioeconomic variables, such as maternal education and access to health care, are also spatially determined (Manda 1999, Woods 2003). For example, there are unique risks arising from living in an urban vs. rural setting and, as outlined in Balk and Pullum et al., 2004, urban/rural measures (Gupta and Baghel 1999, Woods 2003), alongside climactic variation (Curtis and Hossain 1998, Findley et al. 2002), are the most widely explored in the literature dealing with issues that are "intrinsically" spatially-specific and influence health and mortality. Compared to traditional socioeconomic determinants explored in the literature, environmental characteristics are not often considered in "formal analysis" of mortality; even widely available environmental data are not widely explored, such as population density, which will ultimately effect factors such as disease transmission within a community (Balk et al. 2004). Nonetheless, environmental factors play an important role in child survival, even when controlling for socioeconomic variation (Anderson et al. 2002) (See Chapters 3, 4). Although difficult to decipher in an empirical analysis, Rainham and McDowell (2005) found child survival, like all population health outcomes, are clearly linked to the environment.

McKee and Chenet (2002) note Central Asia is plagued by "…an unusual pattern of mortality and struggles with the double burden of infectious and non-communicable diseases" (p. 56). Poor and/or restricted health data on the region is a persistent problem, and thus analysis of mortality and interpreting relevant data has been severely limited. Mezentseva (1990) reported that in the Soviet Republics with the highest rates of infant mortality, infectious, parasitic, respiratory and digestive conditions explained the largest variation—all conditions linked to environmental quality as well as socio-cultural and economic variations. Carlson et al. (1990) performed a study on the determinants of life expectancy and infant mortality in the USSR, focusing on socioeconomic and environmental health variables. Incorporating three cross-sections, female farm workers and cotton fields per female farm worker were significant (positively) in explaining infant mortality, alongside other more traditional determinants.

Jensen, et al. (1997) also studied the effects of ecological degradation in the fSU on health, particularly in the Aral Sea region in Kazakhstan. Exposure to toxic chemicals was correlated with poor health; and lead levels, for example, were 30 times higher in Kazakhstani children than in the control sample from Western Germany. At the household level, Buckley (2003) examined three Republics within the CARs to test, among others, the effects of ethnic and regional variation on rates of anaemia and low weight for age; both factors are of significant concern for child health in the region. Across all estimates, maternal health had the most consistent explanatory power. In the post-Soviet period, healthcare expenditure and access to medical supplies and equipment have declined throughout the CARs, especially in rural areas, resulting in reduced health and particularly for women and children (Buckley 2003). Historically, broad access to education, social services, medical care and facilities throughout the fSU meant literacy rates, medical personnel per capita, and school enrolment rates were well above average for countries of similar economic development (WHO 1996, 1999, DHS 2002).

Even when using within-country data, only slight variation in mortality rates may be explained by traditional economic, environment and social indicators (Schultz 1978). Poor data availability nonetheless has limited investigation of health effects linked to environmental determinants at the household level in the CARs (Buckley 2003) (See Chapter 3). Considerable variation within and among Republics also confounds analysis; alternative methods of examining high mortality rates in the region may therefore be required (Dadabaev 2004). For example, Joyce et al. (1986) emphasize that a well-structured, ecological study can provide evidence of potentially causal relationships between mortality and the environment. Both the circumstances in which people live and work are important determinants of health outcomes linked to the environment, and because such factors are outside the control of the individual in the short run, ecological-level analysis may be appropriate to explore environmental health determinants of mortality (Marmot 1998, 2002) (Chapter 2).

5.3 ANALYTICAL FRAMEWORK

The most widely used framework in the literature in assessing the determinants of mortality was proposed in a seminal paper by Mosley and Chen (1984). In this framework, also known as the proximate determinants framework, the effects of social and economic factors on mortality are estimated via a common set of intermediate variables. The framework identifies biological determinants which bring about death, focusing specifically on the "cumulative series of biological insults" that ultimately result in the death of an infant or child. The approach combines economic determinants with a traditionally medical approach, which generally focuses on causes of morbidity, in order to uncover the "black box" where the factors interact to determine child survival (Mosley and Chen 1984b). Building on this framework, Schultz (1984) proposed a model that is essentially a health production function, where the outcome, child mortality, is the result of observed intermediate variables (Schultz 1984, Gravelle and Backhouse 1987). As Hanmer et al. (2003) note, this approach captures "underlying socioeconomic status" and effects on reduced well-being in the form of high child mortality. The socioeconomic determinants can be measured at the individual, household or community level (as discussed in section 5.4). As seen in Figure 5.1, the five proximate determinants proposed by Mosley & Chen (1984) include maternal, environmental, nutrition, personal health and injury variables. The challenge in determining cause of child mortality is identifying the pathways and, therefore, how the variables act on the proximate determinants to determine health outcomes.

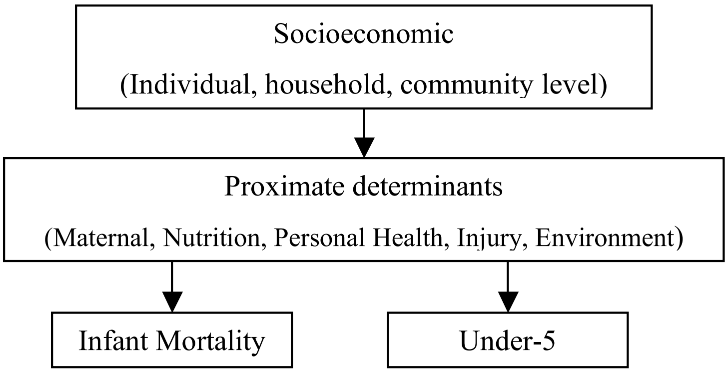


Figure 5.1 Framework for exploring determinants of child mortality. Source: Mosely & Chen (1984)

5.4 THE DATA

5.4.1 Individual

Within the Mosley & Chen (1984) framework, socioeconomic determinants operate on the proximate determinants. These socioeconomic variables can be measured at the individual, household and community level. A key individual level variable explored in the literature as determining a child's chance of survival is a woman's education and health (Caldwell 1979, Waldmann 1992; Pelletier et al. 1993; Schultz 1984; Mosley and Chen, 1984). A woman's knowledge of caring for her child as well as her own health are fundamental to a child's chance of surviving.[22] Birth interval (Hobcraft et al, 1985) and the ability and willingness to breastfeed have likewise been widely considered (Goldeberg et al, 1984; Habicht et al, 1988).

5.4.2 Household

One of the most important household determinants impacting on child survival is income and the distribution of income. There exists a long standing tradition in the literature on the effects of income distribution (relative income hypothesis) and per capita income (the absolute income hypothesis), on mortality and other health outcomes (Deaton 2003). Country level analysis have found mortality is correlated with per capita income (Preston 1975, Rodgers 1979, Pritchett and Summers 1996). Others have focused on the importance of income inequality (Wilkinson 1996, 1997, Marmot 2002). Waldman (1992) tried to disentangle the effects of absolute income on mortality, concluding intra-country variation in both absolute and relative income must be considered. Wildman (2003) noted there is a lack

[22] Mosley (1984) refers to this as "Social Synergy"

of evidence in the health-income relationship and suggests rather that aggregation bias confounds the results between income and health in cross-country analysis. A seminal paper by Rodgers (1979) found income inequality was positively correlated with mortality and since then others have found similar effects on health (Wilkinson 1997, 2002). However, Gravelle (1998, 2000) has voiced scepticism on the use of income distribution data at the aggregate level to explore individual risk of mortality, particularly at higher income levels. Nonetheless, the literature does not specify the precise mechanisms through which income inequality affects health; it will be included in the following estimations as a measure of completeness (Deaton 2003).

5.4.3 Community

At the community level, environmental variables, referred to by Mosley and Chen (1984) as the "ecological setting," the political economy and the health system are all important factors. Access to an improved water source and improved sanitation are the most broadly available examples of ecological level variables explored in connection to child survival. The availability and quality of water is determined at the community level and is thus a factor over which the individual and/or household generally has no control. In both urban and rural populations, access to clean water and improved sanitation is one of the most important factors in human health, with over 1 billion people in the developing world living without access to safe drinking water, while 2 to 3 billion lack basic sanitation (Balint 1999, Buckley 2003). The literature on determinants of mortality finds a strong negative correlation between access to water, improved sanitation and child survival (Schultz 1980). However, within and between country variation presents great barriers to controlling for health risks associated with poor access to potable water and adequate sanitation (Balint 1999, Buckley 2003). The indirect link between poor water quality and sanitation and the end result of mortality makes detecting the relationship between the two difficult, particularly if household level data are unavailable. Esrey (1991) established that safe water is insufficient to reduce infant mortality unless sanitation is also adequate. (Butz et al. 1984) also identified sanitation as being more important than piped (i.e. potable) water, but that when controlling for breastfeeding, both variables were statistically insignificant in explaining infant mortality. Others have found access to piped water was significant in explaining infant death from diarrhoea (Victora et al. 1997). The impact of indoor and outdoor air pollution on child survival has likewise received attention in both the developing and developed literature (Bobak and Leon 1992, Woodruff et al. 1997, Loomis et al. 1999). Access to health care services and quality of services is an important factor in determining child survival, (Mosley and Chen 1984, Matteson et al. 1998) including access by the mother to prenatal care (Eberstein and Parker 1984, Cramer 1987).

Within this study, four proximate determinants were distinguished which affect mortality indirectly via total fertility (and possibly directly as well), including maternal, nutrition, and personal health factors. In addition, there are direct socioeconomic and environmental (built and natural) determinants of mortality. These variables will be discussed in Section 5.5. Under-5 mortality is expected to reinforce the results found with infant mortality and is a more robust measure than infant mortality (Ahmad et al. 2000). Because under-5 mortality conflates infant and child mortality, some researchers have preferred death rates between ages 1-4 (Hanmer et al. 2003). Such data are not available for all countries in the sample.

5.5 DETERMINANTS OF CHILD SURVIVAL EXPLORED WITHIN THIS STUDY

5.5.1 Total Fertility

Fertility is an important correlate of child survival (Schultz 1978, Chowdhury 1988). Like child survival, the total fertility rate (TFR) is influenced by economic and cultural factors (Bongaarts 1978). The direct determinants are intermediate fertility variables known to influence both the quality and quantity of children demanded (Becker and Lewis 1973, Bongaarts 1978, Hill 2003). Such direct determinants are not widely available at the aggregate level. Exploring the relationship between mortality and fertility is limited in an international cross-sectional analysis (Schultz 1978). Potential confounding between the determinants of children demanded and those that survive is problematic in such analysis and has arguably impeded much research in the area. Demographic transition, where a decrease in mortality leads eventually to a decrease in fertility, does not necessarily occur independently from other socioeconomic improvements; fertility reduction does not necessarily lead to a decrease in infant and child mortality (LeGrand and Phillips 1996).

The interrelation between fertility and infant mortality is complex and using an instrumental variable approach is one way to control for endogeneity (Schultz, 1978). Variation between countries at different stages of development could otherwise lead to spurious results in a single cross-section, where such dynamic effects cannot be incorporated (Schultz 1978, Chowdhury 1988). The exclusion of total fertility in mortality estimations, for example in Filmer and Pritchett (1999), is an important omission particularly when using a heterogeneous sample with significant variation between countries. A systems approach is often cited as the most efficient way to deal with covariation in the fertility and mortality equations, but requires the availability of panel data (Schultz 1978). Such data were not available for the selected countries used in the following analysis.

5.5.2 Income

In an attempt to overcome both the limitations posed by traditional measures of absolute income, e.g. GDP per capita adjusted for purchasing power parity (PPP), which does not account for within country variation, and aggregation bias when using income variables, this study investigates the utility of an alternative measure: the consumption of the poor (Cp) (Section 5.4.2). Differing from the approach used by Waldman (1992) also using income distribution, the Cp variable uses within country variation of *real* consumption (not income) of the poorest part of the population, defined in this study as those living on ≤$2 per day. This measure has advantages over the usual measure of GDP per capita income in a cross-sectional analysis which ignores distribution and differing consumption bundles in each country, as well as non-market exchanges, particularly in highly heterogeneous samples (Gravelle and Backhouse 1987). The Cp measure was calculated using data from the World Bank's *PovcalNet* database.[23] See Data Appendix A for the method used to obtain Cp. The share of the population living on ≤$2 per day is an important subset of populations in the countries incorporated in this study. In the former Soviet Union (fSU) alone, over 61 million people continue to live on ≤$2 per day. For all countries used in this study, the mean share of the population (Sp) living on ≤$2 per day (Sp) is 43%. Consumption is a better measure of current welfare than income at low income levels, where non-market activities such as subsistence agriculture are likely to be important. The $2 per day cut off point was chosen as the usual $1 measure of extreme or absolute poverty would have captured too little variation among countries; the $2 per day measure will better reflect rural and urban income differentials in the selection of countries (Chen and Ravallion 2004).[24]

The GINI coefficient is the most commonly used index of income inequality and refers to either household or per capita income. The GINI coefficient is expected to be positively correlated with the dependent variables as greater inequality in income within countries reflects unequal access to health care, nutrition and other services which likely reduce the health of the poor. A seminal paper by Rodgers (1979) found income inequality was positively correlated with mortality, and since then others have found similar effects on health (Wilkinson 1997, 2002). However, Gravelle (1998, 2000) has voiced scepticism on the use of income distribution data at the aggregate level to explore "individual risk of mortality," particularly at higher income levels. Nonetheless, it will be tested in the subsequent analysis.

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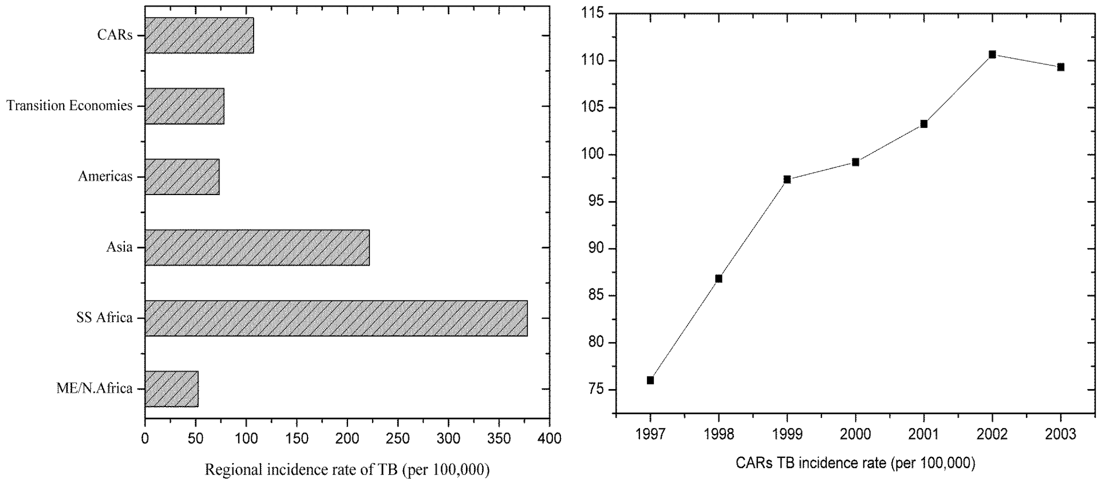
[23] *PovcalNet* is a statistical program designed by Chen, Datt and Ravallion at the World Bank; data can be downloaded for free from http://iresearch.worldbank.org/PovcalNet/jsp/index.jsp

[24] Consulted with Erwin Tiongson at the World Bank regarding use of *PovcalNet* database in the analysis and use of Cp

5.5.3 Environment

Access to an improved water source (IWS) and improved sanitation (IS) are the most widely available environmental health indicators and will be used within the model to proxy factors which can lead to waterborne illnesses (Section 5.4.3). At the international level, omitted variable bias arguably confounds the power of such variables to explain variation in mortality due to indirect contamination routes, and are thus more widely used in analysis of disease-specific morbidity (Murray and Lopez 1997, Buckley 2003). Due to the inherent difficulty in measuring such relationships, well-defined and robust indicators of environmental health are not broadly available, particularly at the national level for cross-sectional analysis. Therefore, in the following analysis, both access to an IWS and IS will be explored.

In contrast to similar cross-country analysis, this study included the female share of the population engaged in agriculture (FAP). This variable operates dually as an environmental health variable capturing the negative affects of occupational exposure to chemical inputs. Economic development is negatively correlated with FAP, so it also operates through socioeconomic determinants. The prevalence of tuberculosis (TB) will be used as a general environmental health indicator. Data for other respiratory illnesses and/or digestive disorders linked to environmental quality were not available for all countries in this study. Tuberculosis is a leading and increasing cause of death in the developing world, and its reduction is one of the Millennium Development Goals (MDG's) (UN 2005) (Figure 5.2). In the CARs, rates of TB have risen sharply since the collapse of the Soviet Union, with poverty, malnutrition and poor housing considered the leading causes (Grange and Zumla 1999, WHO 1999).



(a) (b)

Figure 5.2 Regional TB rates (a) and CARs TB Incidence Rate (b). Source: World Resources Institute (WRI), WHO Health For All Database (HFA DB)

Although routes of contamination are not always certain, chemical pollution in the environment, including the effects of pesticides on mortality, are known to be important factors for long term health (Landrigan 1992, O'Hara 2000). Direct measures of environmental pollutants are not available for the purpose of this study; the most widely accepted environmental measures, including access to an improved water source and access to sanitation, were included. The regional dummy variables are expected to proxy for omitted macro-level environmental factors that are not directly accounted for with the included variables.

5.5.4 Nutrition

To assess the explanatory power of nutritional factors on health, calories available per capita, per day (CALPC) was used. A more direct measure of wasting and stunting in children under five was not used due to missing observations. Malnutrition is a leading cause of death of infants and children and poor maternal health leads to low-weight babies and thus high mortality rates (UN 2005). This variable does not of course capture actual consumption, but its relevance is likely to be enhanced by other controls for the all-important distributional aspects, such as income.

5.6 EMPIRICAL METHODOLOGY

Variables explored within the following analysis are listed in Table 5.1. A cross-section of 61 developing countries was selected to maximize the availability of relevant data in a relatively homogenous sample, and thus allow for a multivariate approach where limited observations for the CARs alone would otherwise prevent such analysis. Data are at the country level and all countries used in the analysis are listed in Data Appendix B. The estimations will be done in two stages: in the first stage, TFR is estimated in terms of the most important socioeconomic variables, which is of interest in itself. The resulting estimate is then used as a well-specified instrumental variable (IV) in the second stage to estimate the mortality equations. As an additional check on robustness, mortality was estimated using the actual TFR as an explanatory variable. The fertility and mortality equations both include inequality indicators among other socioeconomic determinants. Variables aimed at capturing environmental health and spatial factors impacting on health will be included in stage 2 of the analysis only. To capture specific environmental problems in the CARs and other problems in the least developed countries, dummies for the CARs and 5 other regions were introduced (Appendix B). Simple correlations and descriptive statistics are shown in Table 5.2 and Table 5.3, respectively. All equations were arrived at using a general-to-specific approach where the estimated function incorporates all significant exogenous variables; insignificant variables were removed one at a time. The following section describes the equations estimated.

Table 5.1 Source and description of variables tested in the analysis

l	Year	Source	Description
Infant mortality rate (IMR)	Average 2000-2002	WRI	Deaths per 1000 live births between 0-1
Under 5 mortality rate (U5MORT)	Average 2000-2002	WRI	Deaths per 1000 live births between 0-5
Contraception (CON)	Average 1980-2002	WRI	Share (%) of married women aged 15-49 with access to contraception
Total fertility rate (TFR)	Average 1995-2005	WRI	Births per women during reproductive lifetime
Female literacy rate (FLIT)	2004	WRI	Literate share (%) of adult female population
Female participation rate (FPR)	Average 1999-2002	FAO	Female share (%) of total labour force
Female agricultural population (FAP)	Average 2000-2001	FAO	Female share (%) of agricultural labour force
Calories available per capita/per day (CALPC)	Average 1999-2002	FAO	Calories available per capita per day
Health Expenditure (HEX)	Average 1998-2002	WRI	Per capita health expenditures ($)
Medical personnel (MEDS)	Average 1998-2002	WRI	Medical personnel per 100,000
Incidence of tuberculosis (TB)	Average 1999-2002	WRI	Incidence of tuberculosis per 100,000
Mean consumption of the poor (Cp)	2001	WB	Annual mean consumption of those living on ≤$2 per day
Gini Coefficient (GINI)	2001	WB	Coefficient of income distribution where 0 is perfect equality and 1 is perfect inequality
Access to improved water source (IWS)	2002	WRI	Share (%) of the population with access to an improved water source
Access to improved sanitation (IS)	2002	WRI	Share (%) of the population with access to sanitation facilities
Share of poor (Sp)	2001	WB	Share (%) of population living on ≤$2 per day

Table 5.2 Simple correlations of variables used within the analysis

	CALPC	U5MORT	CON	CP	FAP	FLIT	FPR	GDP	GINI	HEX	IMR	IS	IWS	TB	TFR
CALPC	1.00	-0.60	0.56	0.49	-0.12	0.29	-0.30	0.61	-0.08	0.50	-0.61	0.57	0.50	-0.50	-0.62
U5MORT	-0.60	1.00	-0.83	-0.56	0.52	-0.63	0.37	-0.66	-0.01	-0.62	0.98	-0.73	-0.71	0.64	0.84
CON	0.56	-0.83	1.00	0.48	-0.48	0.65	-0.29	0.57	0.00	0.58	-0.82	0.67	0.62	-0.59	-0.81
CP	0.49	-0.56	0.48	1.00	0.03	0.26	-0.17	0.26	-0.57	0.25	-0.51	0.49	0.43	-0.58	-0.59
FAP	-0.12	0.52	-0.48	0.03	1.00	-0.39	0.45	-0.42	-0.37	-0.52	0.55	-0.36	-0.38	0.46	0.33
FLIT	0.29	-0.63	0.65	0.26	-0.39	1.00	0.11	0.48	0.09	0.49	-0.64	0.62	0.42	-0.27	-0.73
FPR	-0.30	0.37	-0.29	-0.17	0.45	0.11	1.00	-0.28	-0.22	-0.34	0.38	-0.23	-0.33	0.45	0.00
GDP	0.61	-0.66	0.57	0.26	-0.42	0.48	-0.28	1.00	0.35	0.86	-0.67	0.66	0.61	-0.37	-0.60
GINI	-0.08	-0.01	0.00	-0.57	-0.37	0.09	-0.22	0.35	1.00	0.42	-0.03	-0.08	0.08	0.31	0.16
HEX	0.50	-0.62	0.58	0.25	-0.52	0.49	-0.34	0.86	0.42	1.00	-0.63	0.55	0.50	-0.39	-0.53
IMR	-0.61	0.98	-0.82	-0.51	0.55	-0.64	0.38	-0.67	-0.03	-0.63	1.00	-0.77	-0.72	0.66	0.83
IS	0.57	-0.73	0.67	0.49	-0.36	0.62	-0.23	0.66	-0.08	0.55	-0.77	1.00	0.76	-0.68	-0.75
IWS	0.50	-0.71	0.62	0.43	-0.38	0.42	-0.33	0.61	0.08	0.50	-0.72	0.76	1.00	-0.57	-0.60
TB	-0.50	0.64	-0.59	-0.58	0.46	-0.27	0.45	-0.37	0.31	-0.39	0.66	-0.68	-0.57	1.00	0.57
TFR	-0.62	0.84	-0.81	-0.59	0.33	-0.73	0.00	-0.60	0.16	-0.53	0.83	-0.75	-0.60	0.57	1.00

Table 5.3 Descriptive statistics

	Mean	Max	Min	Std. Dev.
CALPC	2505.57	3389.00 Romania	1635.40 Burundi	413.81
CMORT	71.81	206.50 Mozambique	8.50 Malaysia	57.95
CON	49.47	78.50 Vietnam	5.60 Mozambique	20.05
Cp	493.13	703.05 Dominican Republic	246.74 Central African Republic	101.89
Sp	42.95	90.67 Nigeria	0.19 Dominican Republic	25.98
FAP	36.92	65.26 Jordan	3.60 Panama	16.93
FLIT	75.23	99.50 Russia	26.40 Nepal	23.39
FPR	40.47	52.27 Cambodia	24.06 Jordan	7.55
GDP	3853.66	9479.40 Chile	594.20 Malawi	2510.23
GINI	43.39	74.33 Namibia	27.03 Uzbekistan	11.09
HEX	200.38	714.50 Chile	11.75 Ethiopia	155.84
IMR	49.89	129.00 Mozambique	8.00 Malaysia	33.38
IS	59.07	100.00 Bulgaria	5.00 Ethiopia	23.07
IWS	76.66	100.00 Bulgaria	23.50 Ethiopia	16.37
MEDS	122.02	417.20 Russia	1.90 Rwanda	114.00
TB	175.93	633.73 Namibia	6.40 Jordan	161.54
TFR	3.50	7.16 Yemen	1.12 Bulgaria	1.51

5.6.1 Stage 1: Total Fertility

Within the first stage of the analysis, the fertility equation was specified as follows:

$$\mathrm{TFR}_i = \acute{a}_0 + \acute{a}_1\mathrm{CON} + \acute{a}_2\mathrm{FPR}_i + \acute{a}_3\mathrm{FLIT}_i + \acute{a}_4\mathrm{GINI}_i + \acute{a}_5\mathrm{H}\mathit{EX}_i + \acute{a}_6\mathrm{D} + \tilde{o}_i \qquad (1)$$

Access to contraception (CON) is likely to be a key determinant of a population's fertility (Bongaarts 1997). In the sample of countries this variable is highly (negatively) correlated with infant and child mortality as well as total fertility (Table 5.2). The female participation rate (FPR) is a variable signifying opportunity cost of child rearing; because more children limit a woman's ability to participate in the labour force, FPR should be negatively correlated with total fertility (Gregory and Campbell 1972, Anker 1978, Conger and Campbell 1978).

FPR is likely to be endogenously determined by cultural and economic factors affecting the role of women in the labour market and the family (Bongaarts 1978, Conger and Campbell 1978). Here, however, it is assumed FPR is exogenous. Market data, including wages and unemployment for all countries, were not available to allow a structural equation to be estimated for FPR. The Hausman test will be used to test this assumption.

Female education is well-known to be of primary importance for child survival as well as fertility (Schultz 1978, Repetto 1979, 1986, Waldmann 1992, WHO 1999). A proxy for female education will thus be used in both stages of the analysis; education data were unavailable for the entire sample, therefore the female literacy rate (FLIT) was used as a proxy for educational attainment.

Fertility is related to income inequality and to allow for such effects, the most common measure of income inequality, the GINI coefficient, was used (Kremer and Chen 2000). The Cp variable was tested in (1) but was insignificant, due likely to multicollinearity with the GINI variable. The per capita expenditure on health (HEX) was also included and is highly correlated with GDP in the bivariate correlations and thus may act as a proxy for GDP per capita. Previous research in the area has found public health expenditure (HEX) explains little if any variation in mortality in cross-national studies (Filmer and Pritchett 1999). Confounding arguably reduces the explanatory power of this variable in such cross-sectional studies. Nonetheless, the effects of public health expenditure on mortality will be estimated indirectly by incorporating HEX in (Eq.1). The HEX measure is expected to be negatively correlated with total fertility since health services are related to availability of family planning (Bongaarts 1978, Schultz 1984). Medical personnel was tested but removed from the final estimations because this variable essentially acts as a dummy for the transition economies of Central and Eastern Europe and the CARs (Figure 5.3).

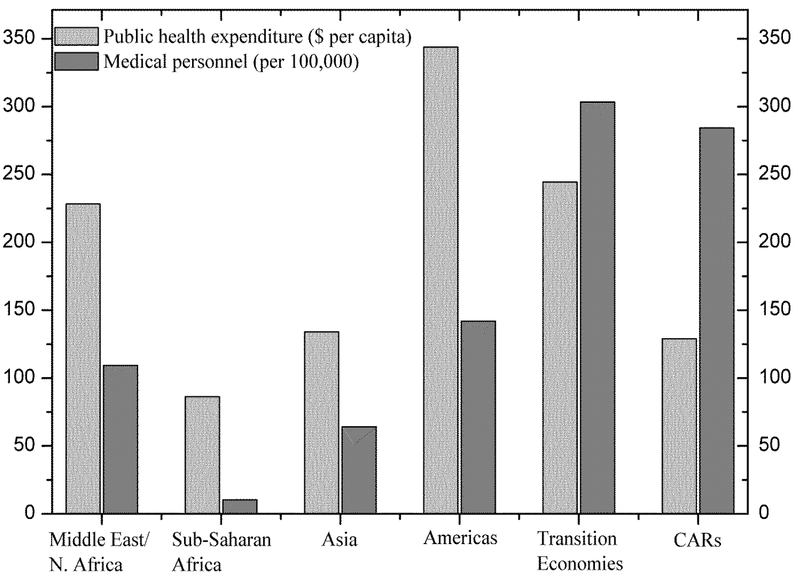


Figure 5.3 Regional variation (Avg. 1998-2002) in health care indicators. Source: World Resources Institute (WRI).

In (1), D represents a vector of 5 regional dummy variables, plus the CARs which is the reference region for all estimations; because the CARs are the countries of primary interest, the results are interpreted against this regional grouping. The two-stage approach conserves degrees of freedom in the mortality equation, while specifying an appropriate instrumental variable (IV) for total fertility and allowing for any reverse causality between the two. The use of an IV for TFR in the subsequent mortality equations will thus allow the influence of factors which affect both total fertility and infant mortality to be seen, while avoiding simultaneity bias (Gravelle and Backhouse 1987). This is important in view of work such as Hanmer et al. (2003), which supports the “reverse causality” or effect of mortality on fertility. Chowdhury (1988) found regional variation and income determine the direction of the relationship between infant mortality and total fertility, with significant variation among countries even when income levels are similar.

5.6.2 Stage 2: Infant and under-5 mortality

The following three equations were estimated in stage two of the analysis:

$$IMR/U5MORT_i = \hat{a}_0 + \hat{a}_1 CALPC_i + \hat{a}_2 Cp_i + \hat{a}_3 FAP_i + \hat{a}_4 IWS_i + \hat{a}_5 TB_i + \hat{a}_6 \hat{TFR}_i + \hat{a}_7 D_i + \tilde{o}_2 \qquad (2)$$

$$IMR/U5MORT_i = \hat{a}_0 + \hat{a}_1 CALPC_i + \hat{a}_2 Cp_i + \hat{a}_3 FAP_i + \hat{a}_4 IWS_i + \hat{a}_5 TB_i + \hat{a}_6 TFR_i + \hat{a}_7 D_i + \tilde{o}_3 \qquad (3)$$

$$IMR/U5MORT_i = \hat{a}_0 + \hat{a}_1 CALPC_i + \hat{a}_2 Cp_i + \hat{a}_3 FAP_i + \hat{a}_3 FLIT_i + \hat{a}_4 TB_i + \hat{a}_5 D_i + \tilde{o}_4 \qquad (4)$$

In specifying the child mortality equations, total fertility was first incorporated as an IV to obtain the first mortality equation (2). For comparison, the possibility of simultaneity was ignored and the estimated value for fertility was replaced with TFR as an explanatory variable in (3). Finally, to obtain (4), all exogenous variables were first used from (1)–(3). A general-to-specific procedure was followed to eliminate insignificant regressors, one by one, to arrive at specification (4). Regional dummies were added in each case as discussed in the results section (5.7).

5.7 RESULTS

Prior to estimation, all explanatory variables were examined for distribution and multicollinearity. Child mortality can be modelled either as a continuous variable or as a discrete variable, depending on available information (Schultz, 1984) and both approaches are employed in the literature. Due to the large cross-section of countries used within this study, only rates of infant and under-5 mortality were available for all countries and therefore ordinary least squares (OLS) was used. Calculations were performed using EViews V. 5. All variables were log- transformed to improve pairwise linearity. The White correction was used to control for heteroskedasticity (EViews 2004). Both Cp and GINI were tested, but Cp was insignificant at the 10% level or better and thus removed. The GINI coefficient was excluded from (2) as it is included in (1) and its effects will be estimated indirectly; when included simultaneously with Cp, the GINI became insignificant and was thus excluded from (3) and (4). Both the results for IMR and U5MORT are reported. As was expected due to U5MORT covering a longer time period of potential deaths, the results for IMR had comparatively lower explanatory power for all three specifications with all coefficients slightly smaller, but similarly significant.

Table 5.4 Results for total fertility

Dependent Variable: Total Fertility White standard errors & covariance (no d.f. correction)		
N=61	Equation 1	
C	3.60***	3.88***
	4.03	**3.64**
CON	-0.22**	-0.22**
	-2.35	**-1.99**
FLIT	-0.23**	-0.20***
	-2.26	**-2.48**
FPR	-0.56***	-0.38*
	-2.76	**-1.59**
HEX	-0.25***	-0.13***
	-3.85	**-2.80**
GINI	0.71***	0.28**
	4.93	**1.78**
CARs	Reference Region	
Central/Eastern Europe		-0.61***
		-6.40
Americas/Caribbean		-0.03
		-0.27
North Africa/Middle East		-0.07
		-0.60
South/East Asia		-0.05
		-0.59
Sub-Saharan Africa		0.10
		0.75
Adjusted R-squared	0.72	0.84

NB: t-stats in bold * Sig=.10 **Sig=.05 ***Sig=.01

5.7.1 Stage one: Results for total fertility

The results from the first stage of the analysis are reported in Table 5. 4. The model was well specified with an Adjusted R^2=.72, indicating $\hat{TFR}$ is a good IV for stage 2 of the analysis. All explanatory variables were significant at the 10% level and signed in the expected direction. In contrast to the simple correlation, FPR is significantly negative, indicating a higher employment among females leads to lower total fertility, as would be expected (Section 5.6.1). The Hausman test showed no simultaneity between total fertility and FPR. The GINI coefficient was highly significant with an elasticity of 0.71, supporting previous findings that income distribution is an important determinant of fertility outcomes (Kremer and Chen 2002). The Cp variable was tested and removed as it was insignificant and this may be due to multicollinearity between the GINI and the Cp.

Of the regional dummy variables in (1) all were negatively signed, however, only the dummy for Central/Eastern Europe was significant at the 10% level. The dummy variables increased the overall explanatory power of the model to an Adjusted R^2=.84. The results indicate total fertility in the CARs is not significantly higher after controlling for variables considered to be the most important in determining total fertility, demonstrating that traditional socioeconomic factors are adequate to explain fertility rates in the CARs.

5.7.2 Stage two: Results for infant mortality

The results for infant mortality for stage 2 are reported in Table 5.5. In (2), only IWS and Cp were insignificant at the 10% level. An estimated value of TFR from (1) was used as this specification was designed to control for any simultaneity in the fertility-mortality relationship. The Hausman test was performed to check for such simultaneity but was insignificant. The insignificance of Cp was not unexpected due to the inclusion of estimated total fertility in this estimation which includes income distribution and, therefore, the effects of Cp on IMR are expected to lose explanatory power due to multicollinearity with the GINI variable. Equation 2 has high explanatory power, increasing with the inclusion of regional dummy variables, as seen in the Adjusted R^2 moving from .73 to .81. Only TB becomes more significant with the dummy variables. In (2) all regional dummies were negatively signed and significant at the .10 level or better.

Table 5.5 Stage 2 Results for Infant mortality

Dependent Variable: Infant mortality
White standard errors & covariance (no d.f. correction)

N=61 (balanced)	Eq.2		Eq.3		Eq.4	
C	9.17***	7.61***	8.19***	7.61**	16.79***	14.11***
	3.37	**2.13**	**2.37**	**2.04**	**6.42**	**6.02**
CALPC	-0.88***	-0.77***	-0.61**	-0.54	-1.17***	-0.92
	-3.11	**-2.51**	**-1.88**	**-1.41**	**-4.06**	**-2.98**
CP	0.00	0.09	-0.14	-0.12	-0.59**	-0.35*
	0.00	**0.38**	**-0.59**	**-0.60**	**-2.13**	**-1.54**
FAP	0.31***	0.30***	0.31***	0.25**	0.32***	0.25***
	5.65	**3.07**	**6.64**	**2.51**	**5.26**	**2.74**
FLIT					-0.50***	-0.57***
					-5.03	**-4.96**
IWS	-0.26	-0.19	-0.30**	-0.27*		
	-1.33	**-1.00**	**-1.80**	**-1.74**		
TB	0.15***	0.23***	0.13**	0.21***	0.15***	0.22***
	2.62	**4.07**	**2.29**	**4.20**	**2.81**	**3.87**
EST TFR	0.67***	0.67***				
	4.71	**3.46**				
TFR			0.65***	0.73***		
			5.57	**3.68**		
CARs (Reference Region)						
Central/Eastern Europe		-0.73***		-0.31*		-0.81***
		-4.04		**-1.76**		**-5.47**
Americas/Caribbean		-0.46***		-0.48**		-0.54***
		-2.09		**-2.19**		**-2.80**
North Africa/Middle East		-0.37**		-0.29*		-0.44**
		-1.78		**-1.68**		**-2.43**
South/East Asia		-0.82***		-0.74***		-0.91***
		-3.99		**-3.96**		**-4.94**
Sub-Saharan Africa		-0.52**		-0.50**		-0.46**
		-2.35		**-2.83**		**-2.44**
Adjusted R-squared	0.73	0.81	0.76	0.82	0.71	0.82

NB: t-stats in bold * Sig=.10 **Sig=.05 ***Sig=.01

In (3), once again total fertility had the highest magnitude in the model as would be expected, followed by FAP and TB. The income variable, Cp, gains significance slightly but is correlated with TFR (Table 5.2) which reduces the magnitude of the coefficient in the estimation. Just as in (2), the factors most closely linked to decisions of the mother and the household environment have coefficients with the highest magnitudes. CALPC lost significance in this equation due likely to multicollinearity with TFR (p = -.62) as the higher the number of infants in the household, the fewer available calories per capita. With the inclusion of regional dummies, the overall explanatory power of the model increased from .76 to .82; once again all regions showed lower infant mortality than the CARs; the regional dummies for Eastern/Central Europe and North Africa/Middle East were just significant at the 10% level.

After first including all exogenous variables used in (1) and (2), insignificant variables were removed in a general-to-specific procedure resulting in the specification for (4). Equation 4 was the best specified of the three, and like (2) and (3), gained significance with the inclusion of the regional dummies. The income variable, Cp, became significant at the .05 level as TFR and an estimated value of TFR were excluded from this estimation. Therefore, (4) is controlling directly for the consumption of the poorest share, with no multicollinearity effects from the income distribution measure incorporated in (1) or with TFR in (2). Also highly significant in (4) were FLIT and CALPC, variables capturing nutrition and literacy rate of the mother, respectively. Both variables are important in determining infant survival and especially in the poorest Sub-Saharan countries, where rates of both are lowest. All regional dummies were once again negatively signed and significant at 5% level, and show lower infant mortality compared to the CARs.

5.7.3 Stage two: Results for under-5 mortality

The results for under-5 mortality for stage 2 are reported in Table 5.6. Equation 2 had high explanatory power with an Adjusted R^2 =.76. As with the estimations for IMR, (2) was designed to control for simultaneity with total fertility (as estimated in (1) and the Hausman test was used and found to be insignificant. All variables were correctly signed. In (2), Cp and IWS were insignificant at the 10% level. CALPC had unit elasticity and FAP and estimated TFR had the highest significance levels. The regional dummy variables were then included (2) and the overall explanatory power increased to Adjusted R^2=.83; while the coefficient of TB almost doubled, the magnitude of the other variables was reduced. IWS remained insignificant at the 10% level, as did IS in unreported regressions. High multicollinearity between these variables was a problem and thus they were not included together. Cp also remained insignificant.

Table 5.6 Stage 2 Results for Under-5 Mortality

Dependent Variable: Under-5 Mortality
White standard errors & covariance (no d.f. correction)

N=61	Eq.2		Eq.3		Eq.4	
C	11.69***	8.68**	10.78***	9.02***	20.76***	16.44***
	4.05	**2.38**	**3.01**	**2.34**	**7.19**	**6.35**
CALPC	-1.06***	-0.87***	-0.75**	-0.63	-1.41***	-1.06
	-3.34	**-2.57**	**-2.08**	**-1.46**	**-4.16**	**-3.02**
CP	-0.17	0.05	-0.35	-0.22	-0.87***	-0.48*
	-0.62	**0.19**	**-1.29**	**-0.89**	**-2.52**	**-1.58**
FAP	0.36***	0.37***	0.36***	0.30**	0.37***	0.30***
	6.07	**3.34**	**7.16**	**2.72**	**5.67**	**3.13**
FLIT					-0.57***	-0.65***
					-5.35	**-5.55**
IWS	-0.30	-0.20	-0.35	-0.30		
	-1.38	**-0.93**	**-1.82**	**-1.66**		
TB	0.15**	0.22***	0.13**	0.20***	0.15	0.21***
	2.46	**3.46**	**2.05**	**3.35**	**2.61**	**3.14**
EST TFR	0.79***	0.80***				
	5.30	4.13				
TFR			0.75***	0.83***		
			6.13	**4.19**		
CARs (Reference Region)						
Central/Eastern Europe		-0.79***		-0.31*		-0.88***
		-4.17		**-1.72**		**-5.80**
Americas/Caribbean		-0.44*		-0.46**		-0.52**
		-1.83		**-1.92**		**-2.51**
North Africa/Middle East		-0.46**		-0.36**		-0.52**
		-2.10		**-1.89**		**-2.70**
South/East Asia		-0.85***		-0.75***		-0.94***
		-3.87		**-3.78**		**-4.80**
Sub-Saharan Africa		-0.43*		-0.40**		-0.34*
		-1.80		**-2.04**		**-1.66**
Adjusted R-squared	0.76	0.83	0.79	0.83	0.74	0.84

Note: t-stats in bold * Sig=.10 **Sig=.05 ***Sig=.01

In (3), TFR was included as a regressor alongside the variables used in (2), for comparison with the IV estimate from (1). In this specification, the overall explanatory power was slightly higher with an Adjusted R^2=.79. Like in (2) for IMR, Cp was insignificant at the 10% level and this is likely due to high multicollinearity with TFR. IWS had slightly higher significance in these two estimations and was insignificant at the 10% level. The Hausman test for simultaneity between TFR and child mortality was negative. As in the estimations for IMR, CALPC became insignificant at the 10% level due likely to multicollinearity with TFR. With the inclusion of regional dummies in (3), the explanatory power of the model increased to an Adjusted R^2=.83. It is concluded that in the sample, simultaneity is not a problem and that (3) is well-specified.

As for infant mortality, to arrive at (4), all explanatory variables used to explain (1)-(3) were tested in a general specific approach and removed for insignificance. The variables which remained significant and correctly signed were CALPC, TB, FAP, Cp and FLIT. Key variables that jointly explain TFR and infant and under-5 mortality were FLIT and Cp, while CON, FPR, GINI and HEX were only significant in explaining TFR. The insignificance of HEX in the mortality equation reinforced findings in the literature (Section 5.3.2). The elasticity of Cp in (4) was slightly above the range reported in the literature for an income variable (Filmer and Pritchett, 1999), although it was not quite significant at the .10 level or better with the inclusion of the dummies. The CALPC had the highest explanatory power in (4) with greater than unit elasticity; it is highly correlated with GDP and may be acting as a proxy variable for income (GDP was not used in the estimation so multicollinearity is not a problem; Cp was used as a proxy for income and CALPC and Cp were correlated at p=.50). The regional dummies included in (4) were all negatively signed and significant at the .10 level or better in (4), indicating lower under-5 mortality than in the CARs (the reference region) after controlling for the traditional determinants captured by the model's explanatory variables. All variables apart from Cp remained significant at the 10% level. The explanatory power of the overall model increased with the regional dummies to an Adjusted R^2=0.84.

5.8 Discussion

The dummies for all other regions were negative and significant at the 10% level or better compared to the CARs for both IMR and U5MORT—indicating that after controlling for traditional socioeconomic and other important proximate determinants, IMR and U5MORT in the CARs is comparatively higher than all other regions.

Variation between the estimations for under-5 and infant mortality was not highly significant. As was expected, the model for IMR explained a greater share of variation between regions than the U5MORT model. As discussed in previous sections, infants are more vulnerable to the direct socioeconomic conditions within the household and particularly the health and well-being of the mother. Therefore, based on the variables included in the model, a significant share of mortality within the CARs and the other regions included in the study was explained. For example, after controlling for the most important socioeconomic factors and improving the efficiency of the estimators in (4) for both IMR and U5MORT, the predicted value of infant mortality from the model for the CARs was 58/1000, demonstrating our model explained all but 1.73% of the infant mortality attributable to living in the region.

For the U5MORT estimations, the predicted value in (4) was nearly 70-thus leaving nearly 8% of U5MORT in the CARs unexplained by the fundamental variables included in the model.[25] This larger share of unexplained mortality (than for the estimations for IMR) is not unexpected and supports the assumptions that factors outside the home play a greater role in explaining U5MORT than for IMR. Nonetheless, one cannot know what share of the unexplained mortality for U5MORT is due to omitted variable bias and what share is due to the value for U5MORT simply being higher. As previously stated, U5MORT conflates the infant and child mortality (deaths between 1 and 4) rates and does not allow us to differentiate between those factors in the model that act most heavily on infants age 0 to 1 and those on children between 1 and 5. Arguably, if the values used in the estimation for infant and under-5 mortality reflected more accurately true rates in the CARs (see Chapter 4), then it is likely an even greater share of mortality attributable to the region would not be captured by the included variables alone; and an even larger share of child mortality in the CARs would be left unexplained. Furthermore, if considering infant and child mortality rates in Western Europe and/or other CIS countries excess mortality attributable to living in the CARs is not a small value at approximately six deaths per 1000 based on the mean U5MORT rate. Based on WHO estimates, the average under-5 mortality for the EU-15 countries in 2005 was 5.65/1000 and 18/1000 in the CIS countries. The excess mortality due to living in the CARs is not a nominal value, particularly after having controlled for the determinants most traditionally of interest on the policy agenda.

What the model also allows us to see is that in contrast to Sub-Saharan Africa where the absolute U5MORT is highest out of all other regions, the predicted value from the model is higher for this region than for the CARS. That is, the effect on under-5 mortality attributed to living in Sub-Saharan Africa is nearly 138/1000; therefore based on the mean under-5 mortality rate of 146, the model explained all but 5.78% of under-5 mortality in this region. Literacy rates are amongst the lowest in Sub-Saharan Africa and this is reflected in the fact that the model explained a much smaller share of infant mortality in Sub-Saharan Africa when the FLIT was excluded (3).

A further robustness test was made by including GDP in (4) for both infant and under-5 mortality and the Adjusted R^2 increased only slightly (Table 5.7). In the under-5 estimations, CALPC lost significance, though its simple correlation with GDP of 0.59 was not excessive.

[25] There was an error in the reported share of unexplained mortality in a related estimation published in Franz, J., FitzRoy, F., Child Mortality and the Environment in Developing Countries, *Population and Environment* (2006) vol. 27(3), p. 263-284.

All regional dummies maintained similar levels of significance, apart from sub-Saharan Africa which became insignificant at .10 or better and North Africa/Middle East changed from the .05 to .10 significance level for under-5 mortality. The results confirm the specification of (4) for both infant and under-5 mortality as GDP is widely considered the most important explanatory variable for mortality, but did not significantly improve the overall explanatory power of either model.

Table 5.7 Robustness results for infant and under-5 mortality—inclusion of GDP

N=61	Infant Mortality		Under-5 Mortality	
	(13)	(14)	(15)	(16)
C	13.02***	11.89***	16.21***	13.57***
	4.04	**4.03**	**4.60**	**4.21**
CALPC	-0.47	-0.51*	-0.56	-.53*
	-1.10	**-1.42**	**-1.20**	**-1.36**
GDP	-0.28***	-0.17**	-0.33***	-.22**
	-2.80	**-2.09**	**-3.08**	**-2.46**
Cp	-0.55**	-0.33	-0.82***	-.445*
	-2.01	**-1.23**	**-2.76**	**-1.53**
FAP	0.23***	0.19*	0.27***	.22*
	2.74	**1.64**	**2.87**	**1.76**
FLIT	-0.37***	-0.46***	-0.41***	-.51***
	-2.67	**-3.47**	**-2.72**	**-3.46**
TB	0.14**	0.21***	0.14**	.20***
	2.18	**3.31**	**1.97**	**2.86**
CARs	Reference Region			
		-0.75***		-.80 ***
Central/Eastern Europe		**-4.21**		**-4.12**
		-0.39**		-.25
Sub-Saharan Africa		**-1.94**		**-1.17**
		-0.35 *		-.40*
North Africa/Middle East		**-1.70**		**-1.73**
		-0.81***		-.82***
South/East Asia		**-4.69**		**-4.33**
		-0.50***		-.47**
Americas/Carribean		**-2.30**		**-1.98**
Adj. R^2	.75	.83	.77	.85

Note: t-stats in bold * Sig=.10 **Sig=.05 ***Sig=.01

These results also suggest that the use of total fertility and per capita GDP to explain mortality in highly heterogeneous samples including both developing and developed countries is problematic and may yield misleading magnitudes of some key policy variables. For example, in a sample of 116 developed and developing countries, Zakir and Wunnava (2002) used total fertility as an explanatory variable for infant mortality and found it to be highly significant, but did not detect simultaneity. This may be a result of not controlling for regional or country-specific effects to capture the unobserved heterogeneity or stages of social development across their very different countries that Chowdhury (1988) had found to be crucial for the direction of causality. With GDP as their dominating explanatory variable they explain 90% of cross–country variation, but ignore multicollinearity problems. They also found female participation in the labour force to increase mortality, but do not consider the female agricultural participation that was found to be much more important in the final mortality estimations within the analysis. Furthermore, their health expenditure was insignificant and they do not include any macro-level environmental health variables.

In a more comprehensive study of about 100 low to middle-income countries, Filmer and Pritchett (1999) found a simple negative correlation between under-5 mortality and per capita GDP of almost 0.93, with obvious multicollinearity between this and several other variables in what they describe as a "state of the art" equation. Their main result that public health expenditure has no significant effects on mortality is confirmed by the results within this analysis. As an example of the problems raised by using GDP in a heterogeneous sample, their female education variable has a correlation of 0.81 with GDP, and the coefficient values range across estimates from -0.008 to -0.1, though they do not discuss the low estimate or multicollinearity problems. By contrast, the female literacy (FLIT) is stable and significant for both mortality and fertility. Raising FLIT and female education is likely to be an extremely cost-effective policy in developing countries (Desai and Alva 1998).

Filmer and Pritchett's (1999) single environmental health variable (access to safe water) was insignificant and mortality rates in Muslim countries were generally higher. In this study, the CARs are one of two groups of Muslim countries and still the North Africa/Middle East dummy was negatively signed and significant compared to the CARs, showing that religion is not the key factor, and provides further confirmation of the hypothesis that mortality in the CARs cannot be fully captured by traditional variables.

5.9 CONCLUSIONS

Environment and population health determinants vary greatly both within and among countries and traditional emphasis on economic determinants alone does not reveal either the sustainability of a country's well-being and health or the environmental influences on such health outcomes. In contrast to much previous work using fertility to explain mortality, this study identified exogenous determinants of both mortality and fertility. The female literacy rate has the strongest effects in both estimates, but the new measure of consumption of the poor (directly), and income distribution (indirectly), was also significant. The final, general-to-specific choice of independent variables avoids multicollinearity and endogeneity problems, and, when combined with the female share of the agricultural labour force and tuberculosis, at least some of the mortality effects linked to agricultural activities are captured. The results indicate for the first time in an international analysis, therefore, the significant excess mortality attributable to the region. The regional dummies were consistently significant and negatively signed for both IMR and U5MORT, indicating higher rates in the CARs, after controlling for traditional determinants of mortality. The results provide further support for previous medical and epidemiological studies at the individual level emphasising the urgency of addressing high infant and under-5 mortality in the CARs. The work also supports the need to extend the approach to disaggregated, regional level analysis of the CARs (See Chapter 6) to better understand specific factors most imminently determining variation in child survival in the region—factors which are arguably confounded in aggregate, cross-country analysis.

DATA APPENDIX A

A.1 Explanation of the variable Consumption of the Poor (Cp)

The database for measuring consumption of the poor (Cp) draws on 454 surveys covering 97 developing countries and incorporates 93% of the population of the developing world, with over 1.1 million households interviewed, giving an average sample size of approximately 11,000; the distributions are weighted by household size.

Countries with surveys on consumption available in 2001 were used in this analysis.(Chen and Ravallion 2004) Information on total mean consumption, the poverty headcount and gap are utilized to estimate mean consumption of the poorest share of the population. The Cp estimates were obtained by the World Bank's Data group based on a basket of price and consumption data collected by the 1993 International Comparison Project (ICP) which covered 110 countries.

A.2 Calculation of (Cp)

Using the World Bank *PovcalNet* database for 2001

$$Cp = [(PL - (PL * (PG/PH))]$$

Where Cp=consumption of those living on less than $2 per day
PL=Poverty line ($2 per day for this analysis*12 to get monthly consumption)
PG=poverty gap or the mean distance below the poverty line as proportion of the poverty line
PH=Poverty headcount or the % of the population living in households with consumption per person below the poverty line
(Cp * 12) = annual consumption of the poor.

DATA APPENDIX B

B.1 Countries used in analysis by regional groupings

Middle East/North Africa: Algeria, Egypt, Jordan, Morocco, Tunisia, Turkey, Yemen; **Sub-Saharan Africa**: Botswana, Burundi, Cameroon, Central African Republic Ethiopia, Ghana, Kenya, Lesotho, Kenya, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Zambia; **South/East Asia**: Bangladesh, Cambodia, Indonesia, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam; **Americas/ Caribbean**: Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Venezuela; **Central/Eastern Europe/FSU**: Albanian, Armenia, Bulgaria, Georgia, Romania, Russia, Ukraine; **CARs**: Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan

6 An Empirical Investigation of Environmental Health in Uzbekistan

Abstract

The purpose of this chapter is to explore variation in infant mortality in Uzbekistan explained by environmental as well as socioeconomic determinants. In the absence of direct dose-response indicators linking mortality to environmental pollution, theoretically motivated socioeconomic and non-biological variables are used, together with regional dummies, to capture variation in infant mortality in Uzbekistan. This study is unique in its use of oblast data to investigate rates of infant mortality for urban and rural populations, as well as by cause of death. The results indicate there is a lower probability of survival in the Western region of Uzbekistan than in the rest of the country, even after controlling for socioeconomic and non-biological determinants. The Western region is the area most adversely affected by long term monoculture cotton production and the externalities associated with the loss of the Aral Sea. Government policies to reduce infant mortality must consider the role of environmental degradation in determining poor health outcomes and the need to diversify away from the agricultural sector as it drives ongoing environmental degradation throughout the country.

6.1 INTRODUCTION

The purpose of this chapter is explore variation in infant mortality at the oblast level in Uzbekistan and the role of socioeconomic as well as non-biological variables in capturing environmental characteristics that may explain differentials in mortality rates. Infant mortality operates as an environmental health variable as well as providing evidence of health inequality (See Chapter 2), where the impact of living in different regions explains variation in socioeconomic as well as environmental factors that may influence infant survival. To this end, the following hypotheses were tested:

- Variation in infant mortality in Uzbekistan is determined by non-biological factors which proxy for environmental quality, as well as the standard socioeconomic determinants
- Regional dummy variables will explain variation in mortality not captured by socioeconomic and non-biological determinants alone

In the absence of direct dose-response indicators linking mortality to environmental pollution and/or degradation, theoretically motivated socioeconomic and non-biological measures were used to capture variation in infant mortality. Due to limited observations, only key determinants of infant survival broadly defined and employed in the literature were included (See Chapter 4 and 5). Although non-biological variables are expected to impact less on infants (age 0 to 1), than on children aged 1-5, mortality data for children were not available. Nonetheless, the data are disaggregated by rural, urban and mortality from respiratory illness in an attempt to maximize the explanatory power of the independent variables.

Due to limitations in household data availability, *oblast* (administrative) data were used. This study is unique in its use of oblast-level data to investigate the determinants of infant survival in Uzbekistan using a multivariate approach. The data include important socioeconomic and environmental information that is largely outside the control of the household. The use of oblast data avoids a degree of omitted variable bias present in a cross-country study, however, this level of aggregation inevitably confounds some non-biological, social and economic factors which ultimately influence an infant's chance of survival. Socioeconomic and other environmental factors not directly included in the model are captured to the extent possible with the use of regional dummy variables.

The explanatory power of non-biological (spatial) factors which may be important in determining variation in health outcomes in Uzbekistan, such as proximity to irrigation facilities and the related externalities, is a unique contribution of the work. Health inequality has important policy-level implications as it can impact on the direction of spending for various services (such as health care), as well as help to identify determinants of infant mortality that are traditionally ignored due to measurement issues, as well as political and economic priorities, such as environmental degradation resulting from economic activities. While identifying the causal chain of how environmental and socioeconomic determinants impact on infant survival, demonstrating cause-effect remains a distinct challenge.

6.2 THE ECONOMY OF AGRICULTURE IN UZBEKISTAN

Uzbekistan is one of the former Soviet Union Republics (fSU), located in present day Central Asia. Home to over 25 million people, it is the most populous of the five Central Asian Republics (CARs) and the third most populous in the fSU, after Russia and the Ukraine. Uzbekistan is a landlocked country, bordered to the north by Kazakhstan, Kyrgyzstan and Tajikistan to the east, and Turkmenistan to the south. Covering an area of approximately 450,000 km^2, four-fifths of the country is categorized as arid and only 9% of total land area is arable.[26] The country consists of 12 administrative regions or *oblasts,* plus the Autonomous Republic of Karakalpakstan and Tashkent City. The regions are further dissected into *rayons* of which there are 162 in Uzbekistan and 118 cities and towns within these *rayons*. For the purpose of comparison the country can be divided into four areas, as shown in Figure 6.1. As seen in Table 6.1 and Table 6.2, each oblast demonstrates significant variation in population density and geographic variation (See also Data Appendix A.1).[27]

26 Based on author's calculations. The FAO defines arable area as land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category and does not indicate the amount of land that is potentially cultivable. (http://faostat.fao.org/faostat/agricult/landuse-e.htm)

27 Tashkent City is located within the Tashkent Oblast, but it will neither receive independent exposition nor will it be included in the analysis as the population is wholly urban and thus unique from all other administrative regions in our study.

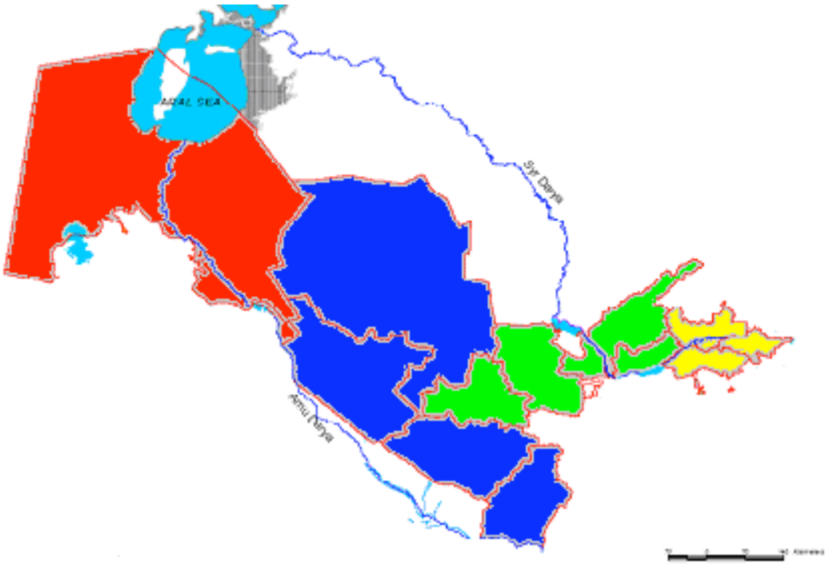


Figure 6.1 Uzbekistan divided by regions: Western (red), Central (blue), East-Central (green), Eastern (yellow)

Table 6.1 Geographic and land use data for Uzbekistan by administrative region (oblast)

2003	Total cropped area ('000 ha)	% of Uzbekistan total	Total arable area ('000 ha)	% of Uzbekistan total	Arable area (ha) per rural capita	% of Uzbekistan highly saline lands (2000)	Irrigated area ('000) ha (2000)	Irrigated area (ha) per rural capita
Uzbekistan	3790.1	100.00	4031.3	100.00	0.25	100.00	4259.00	0.26
Karakalpakstan	285.80	7.60	416.80	10.40	0.53	24.00	500.80	0.64
Andijan	228.80	6.04	196.40	4.87	0.12	1.70	264.90	0.17
Bukhara	236.40	6.24	198.50	4.92	0.19	14.45	273.70	0.27
Dzhizak	407.90	10.76	475.80	11.80	0.67	1.91	300.50	0.43
Kashkadarya	525.90	13.88	664.70	16.49	0.39	8.94	498.10	0.30
Navoi	104.50	2.76	110.70	2.75	0.23	3.54	128.00	0.27
Namangan	219.60	5.79	196.80	4.88	0.16	1.01	278.20	0.22
Samarkand	382.20	10.08	439.40	10.90	0.21	0.51	373.00	0.18
Surhandarya	284.30	7.50	280.50	6.96	0.19	3.32	329.20	0.23
Syrdarya	243.80	6.43	255.80	6.35	0.56	12.59	293.40	0.65
Tashkent	347.00	9.16	333.80	8.28	0.23	0.04	387.10	0.27
Ferghana	291.80	7.70	253.20	6.28	0.13	11.80	356.80	0.18
Khorezm	232.10	6.12	208.90	5.18	0.19	18.46	275.30	0.26

Note: See Data Appendix C for detailed source list

Table 6.2 Demographic data for Uzbekistan by administrative region (oblast)

2003	Total population million	% of Uzbekistan Total Pop.	Pop. density (people per km2)	Urban population ('000)	% Urban	% of Uzbekistan Urban Pop.	Rural population ('000)	% Rural	% of Uzbekistan Rural Pop.
Uzbekistan	25.4	100.00	56.58	9340.7	100.00	100.00	16087.2	100.00	100.00
Karakalpakstan	1.60	6.00	9.40	760.60	47.54	8.00	799.70	49.98	4.90
Andizhan	2.30	8.90	551.20	680.60	29.59	7.29	1599.00	69.52	9.94
Bukhara	1.50	5.73	37.10	445.40	29.69	4.77	1043.70	69.58	6.39
Dzhizak	1.00	3.97	48.90	308.60	30.86	3.26	722.10	72.21	4.45
Kashkadarya	2.30	8.93	81.80	579.70	25.20	6.13	1756.70	76.38	10.71
Navoy	0.80	3.11	7.30	319.00	39.88	3.42	485.00	60.63	2.99
Namangan	2.00	7.83	275.30	755.30	37.77	8.09	1258.40	62.92	7.82
Samarkand	2.80	10.85	168.70	731.60	26.13	7.83	2057.50	73.48	12.79
Surhandarya	1.90	7.14	92.90	357.80	18.83	3.83	1476.50	77.71	9.18
Syrdarya	0.70	2.58	156.30	209.50	29.93	2.24	454.60	64.94	2.83
Tashkent	2.40	9.38	294.80	956.60	39.86	10.24	1455.20	60.63	9.05
Ferghana	2.80	10.76	419.60	790.20	28.22	8.46	1975.50	70.55	12.28
Khorezm	1.40	5.41	231.60	318.70	22.76	3.41	1072.20	76.59	6.66

Note: See Data Appendix C for detailed source list

Agriculture is essential to the Uzbek economy and two main crops dominate production: cotton as a source of income from export and wheat for domestic use (WB 2003). In 2005-2006, Uzbekistan was the 5th largest producer and 2nd largest exporter of cotton in the world. However, the very design and operation of large-scale production in the country is loss making and resource draining; the inefficiency of the sector undermines macroeconomic development. For example, there is a significant lack of incentives for farmers to conserve water as it is subsidised by the state and free.

The inefficient nature of agriculture in Uzbekistan is due in large part to the lack of independence for farmers to choose both what to grow and how. During Soviet times, as at present, land in Uzbekistan is the property of the State and is thus not available for sale or purchase but can be given for use. Unlike in Kazakhstan and Kyrgyzstan, collective farms central to Soviet agriculture were not disbanded after 1991 in Uzbekistan (ICG 2005). With Independence, restructuring took place to expand private access to land; the changes, however, have been described as only “cosmetic” and Uzbekistan is seen as a poor performer of agrarian reform (Oldfield 2000). Agriculture continues to be defined by low productivity and high inefficiency due to resource wasting and low quality production—factors which are poorly tackled under the new land reform agendas (Spoor and Visser 2001). One significant exception has been the augmentation of household plots and peasant farms in the latter half of the 1990’s; nearly all milk and meat production has successfully shifted to the household sector, demonstrating the benefits of farmer decision making in production (Kandiyoti 2003).

Current regulations on land use were established under the Land Code of 1998. The dependence of all agricultural land on state-owned irrigation largely prevents full-privatization of land for the fear of disruption to cotton production (ICG 2005). Cotton is the main export crop and thus the State elite will not jeopardize their command and control of export revenues earned from cotton (Kandiyoti, 2003). With the collapse of the Soviet Union, there was widespread reclassification of land from collective (*shirkat*) to private, small-farmer holdings (*dhekan*). The majority of irrigated arable land is still classified as collective—accounting for over 50% of the value of all crops—consisting mostly of wheat and cotton. As seen in Figure 6.2, official data show a shift in production from *shirkat* to *dhekan* land holdings in recent years, however, the change in farm type is more nominal than actual. Across the country, *shirkat* farms continue to make illegal demands on *dehkan* farms to produce part of their crops to fulfil state quotas (Kandiyoti 2003). In addition, the state still determines all terms of procurement for cotton production; it is up to family farming units, therefore, to exceed quotas in order to share revenue from production.

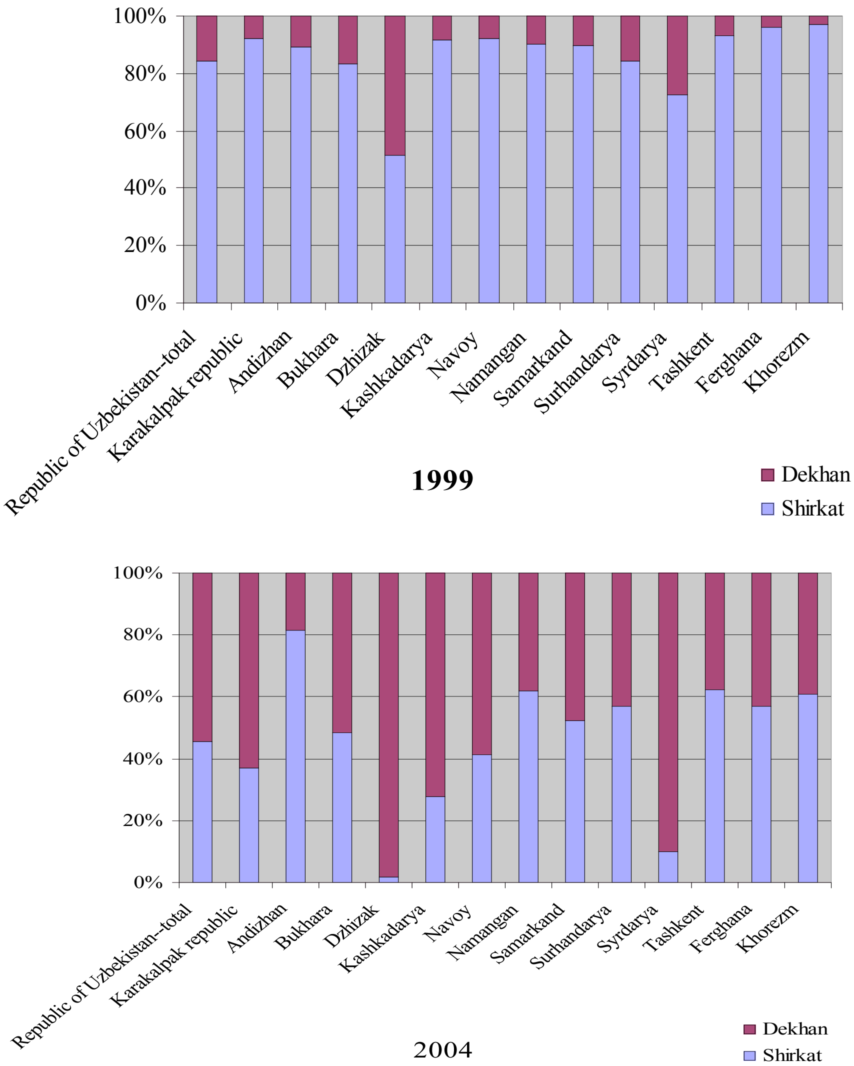


Figure 6.2 Change in land structure from Shirkat to Dekhan, for 1999 and 2004. Source: Data Appendix C

The monoculture cotton industry in Uzbekistan has been in continuous decline during the Post-Soviet era, in both yields and overall production (Figure 6.3). Cotton harvest (tonnes) in the country declined overall between 1999-2003 (Table 6.3), and change in cotton output (hg/ha) varied significantly among oblasts for this period (Figure 6.4). For Uzbekistan's economy, the agricultural sector accounts for 30% of GDP, 60% of foreign exchange receipts and between 30 and 40% of employment (official and unofficial figures vary) (Kandiyoti, 2003). Over the last ten years, a government objective to pursue wheat self-sufficiency has had large implications on changes in cropping patterns, with approximately 30% of irrigated area now sown to wheat (Herman, 1999). Nonetheless, cotton remains the most important crop in the country and accounts for approximately 50% of export earnings or around $US 1 billion annually. Uzbekistan has always been the primary producer of cotton in the CARs and despite its global dominance in cotton production, total investment in this sector averages only 7% of GDP annually; a significant share of which is used to extend the irrigation system (WB 2003).

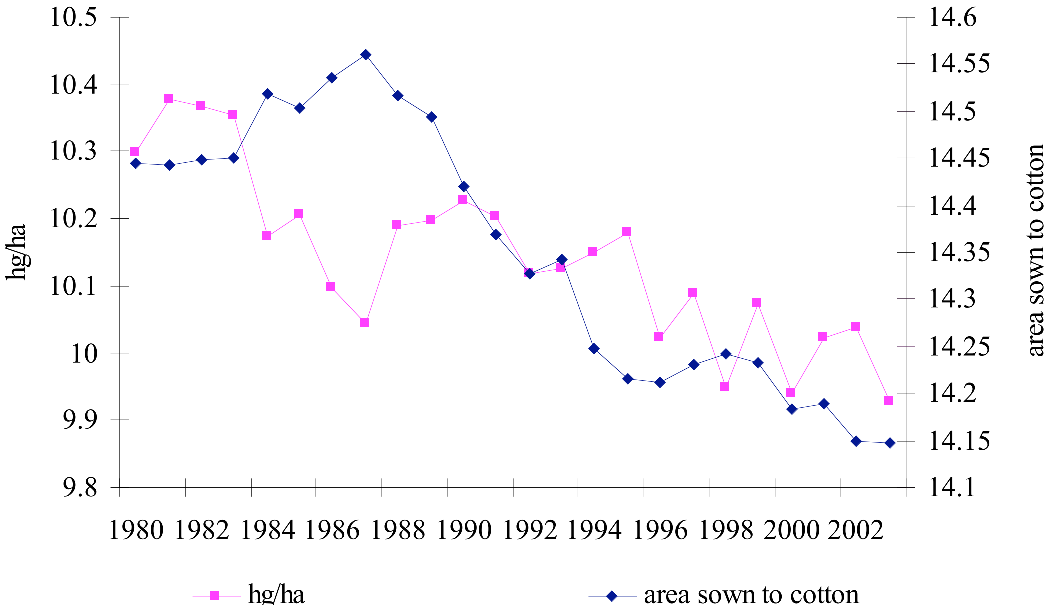


Figure 6.3 Change in Uzbek cotton production in Soviet and post-Soviet period: cotton yields and area sown to cotton (values in logs). Source: FAO

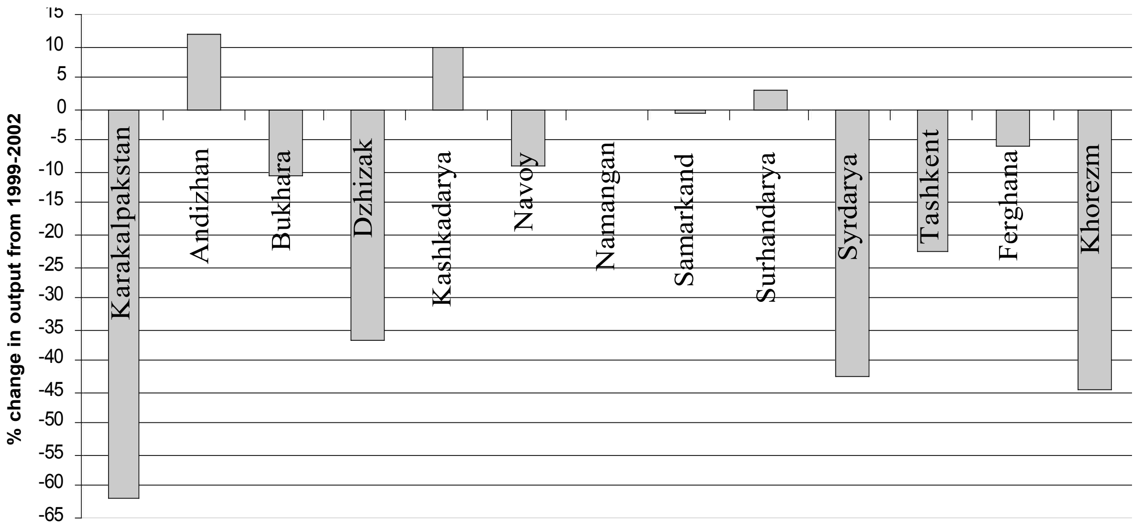


Figure 6.4 Change in output of raw cotton (1999-2002) by oblast. Source: Data Appendix C

Economic performance since 1992 is generally divided into two periods: contraction (1992-1995) and expansion (1996-2001). In the contraction period inflation reached its highest level in 1994 of 1281% (Fischer and Sahay 2000). Decline in GDP was substantially below that of the other CARs and below the CIS average during the contraction period. However, some have noted, including the European Bank for Reconstruction and Development (EBDR), Uzbekistan's high GDP growth could be solely a product of inaccurate growth data (Spoor and Kotz, 2005). In 1995, a decline of 15% in cotton production brought about an economic crisis in Uzbekistan; since 1990 this sector is estimated to have lost more than 65% of its purchasing power as the price of inputs have significantly exceeded the price demanded on the world market for cotton (ICG, 2005). In the expansion period and beyond, there was a significant decline in export earnings, due to both a fall in international prices and output from the cotton sector (WB 2003).

Table 6.3 Variation in cotton harvest by oblast 1999-2002

Total Cotton Harvest ('000 Tonnes)	1999	2000	2001	2002	Harvest as % of Uzbekistan total (2002)
Republic of Uzbekistan (Total)	3600	3002.4	3264.6	3122.4	100
Karakalpakstan	189.4	125.4	111.6	72.6	2.33
Andizhan	331.8	337.4	381.7	372.5	11.93
Bukhara	403.8	351.1	349.3	363.2	11.63
Dzhizak	238.3	156.1	173	150.8	4.83
Kashkadarya	381.7	265.1	325.5	421.3	13.49
Navoi	121.1	103.6	110.4	110.5	3.54
Namangan	239.2	243.5	250.1	239.5	7.67
Samarkand	250.5	167.8	175.8	250	8.01
Surhandarya	310.9	259.5	341.8	320.6	10.27
Syrdarya	241.3	174.8	182	139	4.45
Tashkent	280.6	256.5	277.4	218	6.98
Fergana	321.3	362.6	343.2	303.3	9.71
Khorezm	290.1	199	242.8	161.1	5.16

Source: Data Appendix C

The lack of investment in the agricultural sector since independence has in part made Uzbekistan's economy go from being considered one of the most promising of the Central Asian Economies in the mid-1990's, to one characterized by poor growth, increasing external debt, rising inflation and gross inefficiency (Zettelmeyer 1999; Kandiyoti, 2003). Despite the cessation of transfer payments from Moscow after independence, declines in GDP were tempered in the short run due to favourable initial conditions in Uzbekistan, including low industrialisation, cotton production and self-sufficiency in energy (Zettelmeyer 1999).

In response to the economic crisis between 1994 and 1995, the government responded by introducing a multiple exchange rate system that has become known as the "Uzbek model of development" (Rosenberg and De Zeeuw 2001). Significant welfare losses have been associated with the characteristic three-prong system, where the foreign exchange market is split into three segments, including the official, commercial and curb market rates (Auty, 2003). This has led to a lack of fiscal transparency and discourages foreign investment due to poor accountability and high administrative costs (Rosenberg and De Zeeuw 2001). High inflation continues to be problem, however between 1997 and 2001 inflation stabilised in the 18%-29% range (Spoor and Kotz 2005). Persistently high inflation rates in the country and negative real interest rates discourage savings in the national currency (Rosenberg and De Zeeuw 2001). Some have argued a transition process has hardly begun in Uzbekistan (Fischer and Sahay 2000). There is a sizeable "informal sector" which operates illegally; it has been estimated to account for as much as 35% of GDP in 2002 and an estimate of this sector is included in the official GDP growth data (Spoor and Kotz, 2005).

The high input, low output nature of the agricultural sector is unsustainable for the long run. The government controlled industry is monopolistic in pricing for inputs and cotton continues to be sold at well below market prices. Obstacles in substituting away from agriculture go beyond current government policies and signal a more significant cultural and structural reliance on the sector (Spoor 1998). Uzbekistan is rich in mineral and energy resources, including oil and gas; however, these industries remain under-developed compared to the agricultural industry due in large part to political and historical circumstances combined with competing foreign interests and declining foreign investment (Bartlett, 2001; Akhmedov, 1993; Karimov, 1996). In light of Uzbekistan's economic dependence on monoculture cotton, water supply and land degradation are the most urgent and serious matters for future environmental, social and economic stability in the country (Olimjonov 1999, WB 2003). Improving traditional methods of production would generate welfare gains and, in particular, in the form of improved environmental and population health.

6.3 AGRICULTURE, THE ENVIRONMENT AND HEALTH IN UZBEKISTAN

Officially, an "ecological constitution" forms national policy in Uzbekistan and determines laws on land, natural resources and water usage (Reynolds 1996, Olimjonov 1999). Since gaining independence in 1991, more than 80 laws and government regulatory acts have been adopted on the environment and natural resource use (WB 2003). One of the most important and long term challenges facing the CARs as a whole, and in particular Uzbekistan with the largest population and the greatest reliance on monoculture cotton production, is the re-organization and improved use of resources in order to meet an ever increasing demand for food and agricultural production. The need for improved efficiency in resource use within the

Republics is widely acknowledged, while concrete action to address these issues at the government level is less apparent (WHO 2005; Franz and FitzRoy 2006b)

The threat to the environment, and in turn to human health, from agricultural methods in the country is exacerbated by how cotton is grown (monoculture cropping, inefficient irrigation, and the widespread application of agrochemicals), pollutants associated with cotton (organic endotoxins), and the naturally arid conditions in the country that are particularly vulnerable to desertification and other forms of degradation. As introduced in Chapter 2, the framework used to map the causal link between agriculture and the health outcomes specifically addressed in this chapter, follows the Driving force, Pressure, State, Exposure, Effect (DFPSEE) model, as originally developed for the OECD in 1993 as a tool to identify management options for a range of environmental problems. The leading cause (driving force) of degradation in the region is therefore from agrochemical applications and inefficient irrigation. This leads to a reduction in the quality of land and water in the region (pressure). The implications for land (state) are primarily in the form of salinisation, erosion and ultimately desertification; for water the primary threat is contamination from agrochemical pollutants and shortages in potable water. The consequences of these methods on the human population (exposure) therefore are revealed in the form of poor air, water and land quality. Of greatest threat to health and well-being from air are organic pollutants from cotton production and dust from advancing desertification and the drying Aral Sea bed—the effects of these pollutants are compounded as they are often laced with agrochemicals and salts (due to highly natural saline conditions exacerbated by desiccation of the Sea). Water is likewise not only in short supply, but also widely contaminated with salts and agrochemical pollutants. The outcome (effects) on health are primarily in the form of respiratory illnesses, anaemia, specific types of cancers and an overall reduction in quality and quantity of life for those living in the worst affected regions.

6.3.1 Driving Force

6.3.1.1 Irrigation

At a Party meeting in 1939, it was decided that the Amu darya and Syr darya Rivers should be controlled to "serve" the cause of Socialism and "raise the living standards" of the population, and thus widespread irrigation projects were initiated (Saiko and Zonn 2000). The multi-level, environmental consequences of the inefficient, dilapidated systems are well documented (See Chapter 3). One main outcome of irrigation in the region is salt accumulation and resulting widespread salinisation. As seen in Figure 6.5, salinisation of soils in Uzbekistan continues to worsen, even as the total area sown to cotton in the country has declined. Substitution away from cotton towards other water-intensive crops, such as wheat and rice, exacerbates poor land and soil conditions further.

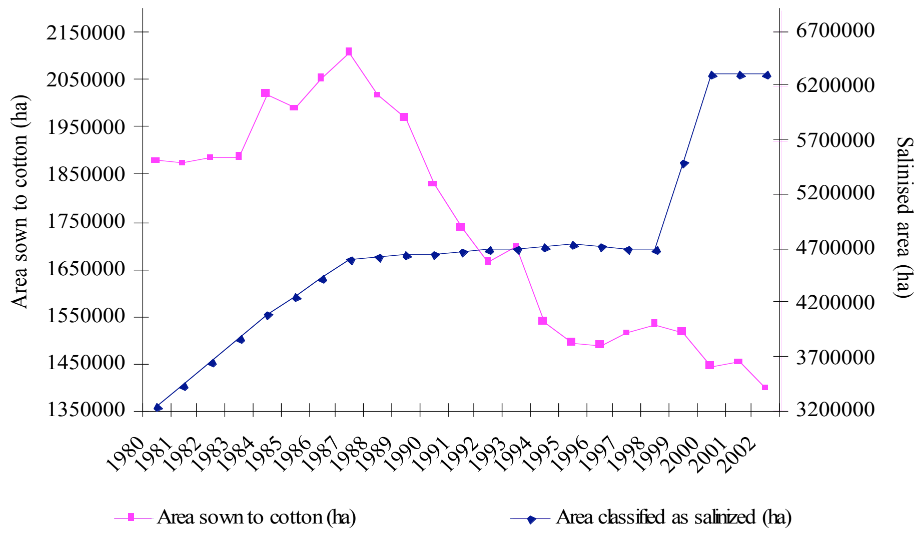


Figure 6.5 Change in area sown to cotton and salinisation of soils in Uzbekistan between 1980 and 2002. Source: 1980-1985 UZGIPROZEM Institute; (1987-2002) Salt and soil survey by the Ministry of Agriculture and Water Management

As introduced in Chapter 3, cotton is a water-intensive crop and production is entirely dependent on irrigation in Uzbekistan. Water diverted for the industry is water that will never reach the Aral Sea, thus desertification of the Aral Sea Basin (ASB) worsens as the Aral Sea disappears. Compounding the problem are water losses in the transportation of irrigation water as structures have eroded significantly over time, are expensive to maintain and are unlined and uncovered. An estimated 70% of total withdrawals do not arrive at the intended location; the multi-level, ecological consequences of the inefficient, dilapidated systems of irrigation are well documented (Spoor 1998, Glantz 1999). Water loss in transport causes water tables to rise and chemical accumulation and contamination along transit routes; large stretches of land are water-logged and heavily salinised as a result. Widespread water-logging and salinisation have reduced soil fertility, resulting in low agricultural production and thus reduced food availability and quality in the face of increasing population pressures. High salinity levels reduce the productive capacity of soil and ultimately agricultural land is abandoned (O'Hara and Hudson, 1999; WHO, 1999; O'Hara et al, 2000).

Costs to run the irrigation system are very high, including energy to run pumps, either to high lands, or to drain low lands. The irrigation system consumes approximately 20% of Uzbekistan's annual energy use and the opportunity cost of the diesel fuel to run the pumps is the border price, not including the negative externalities of air emissions (ICG, 2005).

6.3.1.2 Agrochemical pollution

As introduced in Chapter 3, agrochemical pollution is a key risk associated with agriculture, primarily from pesticide application. Uzbekistan continues to have amongst the highest consumption of agrochemicals in the CARs, accounting in particular for over 70% of all fertilizer applications in 2002. Annual per ha application rates of fertilizers in the Western Karakalpak region are significantly higher than the rest of the country, averaging 70kg per ha, compared to an average application rate of 55 kg per ha (Ataniyazova, 2001). Cotton yields, despite such high chemical and water inputs, are low by international standards, and have been declining in recent decades; yields in Uzbekistan, for example, average 2.6 tons per ha (vs. around 5 tons per ha in other cotton producing countries where irrigation is not required) and these low yields are due to poor management, irrigation and seed quality, combined with mounting environmental stress in the form of salinisation and erosion (Herman, 1999).

6.3.2 Pressure

6.3.2.1 Water

Over 90% of all water used in Uzbekistan goes to irrigation and drainage as the agricultural sector is entirely dependent on irrigation and nearly all water withdrawals are to feed irrigation systems in the ASB. Water use for cotton production accounted for approximately 50% of total water use in Uzbekistan as of 2000 and as much as 93% of total water use in Bukhara goes to cotton production. Uzbekistan has the lowest freshwater resources available per capita out of all other CARs, as freshwater withdrawals continue to exceed total water resources (FAO 2006). The situation has been accurately described as a water management disaster (Micklin 1998). Most waterways in Uzbekistan are reported to be moderately or considerably polluted with over 40% of groundwater unsuitable for drinking (Ballance and Pant 2003).

The water and environmental management problems in Uzbekistan are as acute today as ever before and with the break up of the Soviet Union. Water management issues have become increasingly contentious between the upstream and downstream users in the region, as demand for water causes problems for competing hydroelectric and irrigation needs in the region (Gisladottir and Stocking, 2005; Sievers, 2003). As a downstream user, Uzbekistan is limited to the quantity and quality of water released by upstream Tajikistan and the Kyrgyz Republic. Competing water needs are an increasing concern for economic development and security in the country, particularly in light of current agricultural production methods.

6.3.2.2 Land

The Western region is in the heart of the ASB and is where environmental conditions are the most severe. Data collected by the Uzbek government Division of Ecology and Public Health have led experts in the country to classify the Western region (including Karakalpakstan and Khorezm) as an "ecological disaster zone", while the rest of the country is classified as either "ecologically unstable" or "ecologically near to critical" (WHO, 2001, p. 163). The ASB is the most arid part of the country and arid and semi-arid areas are highly susceptible` to degradation. Land degradation, particularly salinisation and desertification, are worse in this region of the country and there is a large literature on the ecological implications of land degradation due primarily to inefficient irrigation and the many externalities associated with it in the country, including the now infamous desiccation of the Aral Sea.[28] Desertification is exacerbated by natural conditions in the region. The ASB is flanked by the Karakum and Kyzlkum deserts and as much as 50% of the land area in Uzbekistan (Lioubimtseva and Cole 2006). The Virgin Lands campaign started during Soviet times turned more than 40 million ha of previously meadow and pasture area in Central Asia into arable land; myriad consequences of these efforts have evolved, including widespread erosion, salinisation and ultimately desertification (Libert 1995).

6.3.3 State

6.3.3.1 Water

Contaminated water is a considerable health hazard; salts, pesticides and other chemical fertilizers are found in high quantities in public water sources (Muntean et al. 2004). High salinity of water supplies represents a unique health threat to the region (Anderson 1997, Small et al. 2001, WHO 2002b, 2003). The Karakalpakstan, Khorezm and Bukhara oblasts, along with the western Samarkand, Kashkadarya and Djizak and Surkhandarya oblasts, have a real shortage of drinking water due in part to an irregular distribution of groundwater in western Uzbekistan. A lack of sanitation and potable water in rural areas is common and the WHO estimates as much as 10% of the urban population and 40% of the rural population do not have access to piped water in Uzbekistan (WHO 2002b). Other sources cite more than 30% of the total population in Uzbekistan drink and otherwise use water that does not meet national and international quality standards (Semenov and Usmanov 2002, Sullivan and Tureeva 2002). At the same time, treatment facilities use obsolete equipment and are inefficient in processing municipal and industry wastewater (Ballance and Pant 2003). Although agriculture is the primary consumer of the country's water, increasingly the

[28] See Glantz, 1999; Micklin, 1998; Gisladottir and Stocking, 2005; McCauley, 2005

industrial and mining sectors constitute a threat to clean water as they use outdated equipment and severely polluting production processes (Spoor, 1998).

6.3.3.2 Land

The share of cotton output in Uzbekistan is not necessarily correlated with the worst ecological conditions in the country. For example, the Western region of the country, in the heart of the ASB, accounted for only 7.5% of Uzbekistan's total cotton harvest in 2002 Table 6.3). However, while producing less than 10% of Uzbekistan's total cotton harvest, the Western region accounts for nearly 20% of the country's total irrigated area and it is the multifaceted implications of irrigation in the country that pose the greatest risk to environmental and human health. Waterlogging and salinisation from leaking irrigation structures leads to desertification and this is a major problem in all cotton growing regions of Central Asia. As much as 50% of Central Asia is classified as saline (ranging from 89% in Turkmenistan to 12% in Tajikistan) thus contributing widely to advanced desertification and the release of soil into the local and global atmosphere (Lal 2001). As much as 20,000 ha of land in Uzbekistan are lost annually to salinisation (Bucknall et al. 2003).

6.3.4 Exposure

Cotton production in Uzbekistan has primary and secondary implications for health: firstly, from exposure to agrochemicals (Ataniyazova, et al, 2001); secondary implications are from cotton dust (organic endotoxins), and particularly in Uzbekistan where hand picking has become the dominant form of harvesting in the post-Soviet period. The de-mechanisation of cotton production has increased since Independence with as much as 70% of all cotton picked by hand in some regions (ICG, 2005). This de-mechanisation increases exposure to toxic, airborne contaminants, and can have more significant impacts on health and welfare when combined with increasing poverty, income inequality and greater ecological degradation.

In a recent article in the Journal of the American Medicine, the implications of land degradation on human health, primarily in the form of desertification, were highlighted. In particular, the article emphasised the effects of poor agricultural practices on fragile ecosystems and the myriad implications this can have on population health, including "mass migration, famine, massive dust storms, and political instability..." (Kuehn 2006). Desertification from anthropogenic causes has been found to have an indirect effect on changes in dust loads and the size of particles (Bossak 2006). Desertification is a growing threat in China and Wang (2002) noted sand-dust storms have had a significant impact on respiratory health.

6.3.4.1 Cotton pollution

Agriculture is accepted as among the most hazardous occupations, with myriad occupational and environmental threats to health and well-being (Chapter 3). In particular, respiratory hazards are among the most common illnesses associated with the industry; such conditions are chronic among farmers and those working in agricultural-related industries (Kirkhorn, Garry, 2000). The public health threat from agricultural pollution in general, and cotton in particular, is particularly acute in developing countries where occupational and safety regulation is lacking. The impact of organic dust on agricultural workers is poorly investigated as agricultural workers generally constitute a small share of the population and thus it is considered less of an immediate threat to overall public health (Lane and Sewell, 2006).

Agricultural dust exposure, and in particular the effects of organic dust, has been cited as a cause of respiratory disease since the 16^{th} century and continues to be a major source of respiratory morbidity and mortality among agricultural workers (Schenker 2000). Organic dusts originate mainly from plant and animal sources and most commonly result in allergic diseases, including asthma (Eskenazi et al., 1999). Grain dust constitutes a mixture of components, including pesticides, micro-organisms, endotoxins and pollens; the primary source of toxic and allergenic contributors to illness are endotoxins generated from production, harvest, transfer and storage of cotton. In developed countries, such as the United States, there are no regulations on acceptable levels of organic dust emissions, and monitoring of dust levels in agricultural settings is limited (Kinkhorn and Garry 2000).

The organic endotoxins from cotton have been positively correlated with a number of health conditions, and cotton dust exposure leads to respiratory symptoms, including cough, chronic bronchitis and symptoms of breathlessness and tightening of the chest (known as byssinosis) (Su, et al, 2004). Dust associated with cotton is an organic pollutant and the "heterogeneous nature of organic dusts has frustrated efforts to identify specific causal factors" (Lane and Sewell 2006). Therefore, efforts to pinpoint the precise cause-effect (or dose-response curve) between exposure to cotton production and its externalities and the implications on well-being, is confounded by similar difficulties surrounding the identification and linkage between any environmental threat and a specific health outcome. There is, however, conclusive evidence that organic irritants from cotton are positively linked to certain reductions in health outcomes, primarily for respiratory health (Lane and Sewell 2006).

In a seminal article on the link between cotton dust and respiratory function, Rylander et al., (1985) found respiratory function can decrease with exposure to certain bacterial endotoxins associated with cotton dust. Endotoxin exposure from dust is a known correlate of asthma and other respiratory illnesses among children in their first year of life (Laakkonen et al. 2006). Compared to other contaminants, cotton dust has been more strongly associated with chronic airflow limitation than other endotoxins, such as from silk dust (Christiani et al. 1999).

The precise implications of exposure to cotton dust, however, are not fully understood nor does the relationship between the ambient pollutants associated with cotton (primarily bacterial endotoxins), and resulting morbidity, appear to be consistent between study sites. One study investigating the impacts of cotton exposure on cotton mill workers in Britain between 1968 and 1984 found that total mortality from respiratory diseases was lower than expected, however, rates of illness decreased with length of exposure to contaminants (Hodgson and Jones 1990). Evidencing the difficulty in determining what share of the morbidity can be positively associated with exposure to cotton contaminants, however, those with already weakened lungs (controlled for by identifying smokers vs. non-smokers) demonstrated a higher rate of byssinotic symptoms and tightening of the lungs. Such findings support the hypothesis within this chapter, that where health may already be reduced, such as in the Western region of Uzbekistan, there is a greater risk of falling ill from ambient pollutants, than under conditions of full environmental and human health. The study also pointed to a widely observed effect in the epidemiological literature known as the survivor effect—(or the healthy worker survivor effect)—that is the tendency for unhealthy workers to move away from a particular industry impacting negatively on health (Su et al, 2004). Therefore, in the Hodgson and Jones (1990) study, rates appeared lower among those workers who remained within the cotton textile mill and there was a reverse correlation detected between rate of illness and length of service.

In a similar study looking at the implications of cotton dust vs. silk dust on respiratory health in a cohort of textile workers in China, it was found that implications from cotton dust, including byssionsis, were found to be higher among smokers than non smokers; when compared to silk workers, no similar byssionsis was found and only 10 % of silk workers (vs. 23% of cotton) suffered from tightening of the chest. Chronic illnesses, such as coughing and bronchitis, were more common among the cotton workers, with a declining incidence among those who left cotton mills (Wang et al. 2003).

6.3.4.2 Contaminated respirable dust

In Uzbekistan, air quality is severely affected by the drying of the Aral Sea bed; dust storms impact not only on the quality of life for those living in the region, but significantly reduce their health. Respiratory illnesses are a leading cause of death in the region, as are cancers of the respiratory tract; rates of oesophageal cancer have been found to be among the highest in the world. It has been estimated that over 60% of all respiratory illnesses are linked to poor environmental conditions (Bruce et al. 2000, WHO 2002b) including air pollution from wind blown dust contaminated with pesticides and salts; childhood pneumonia in Karakalpakstan is higher than any other region in the (Whish-Wilson 2002).

Naturally arid and semiarid conditions in the ASB render land highly susceptible to desertification—a result of widespread desiccation and loss of productive soils due to erosion and salinisation from anthropogenic activity (Grainger 1990, Lal 2001).[29] Dust deposition rates in the region are amongst the highest in the world, with the frequency of dust storms increasing as more and more sea bed is exposed; the crisis has prompted the WHO to call for urgent analysis of respiratory health problems associated with contaminated dust (O'Hara et al. 2000). Annual removal of dust/sand from the seabed was estimated at 53 million tons in 1990 and up to 57 million tons when including the ASB as a whole (Tokacheva et al. 2004). Epidemiological studies from other parts of the world have shown serious health effects are associated with wind-blown mineral dust, including an increase in the incidence of acute respiratory infections (ARIs) in children (Jensen et al. 1997; Raloff 2001)

In a study focused specifically on understanding the health implications of dust particles contaminated with pesticides in the ASB, O'Hara et al. (2000) identified two key findings. Firstly, in sites located nearest irrigated areas, dust contaminants were greater and pesticide concentration in dust samples was also greatest at sites located in irrigation zones. Secondly, the study reported that where dust deposition rates were highest, there was actually a lower frequency of respiratory illness among children. Although there was no direct explanation offered for this unexpected finding, Wiggs et al., (2000) point to the complex nature of environmental and human health relationships, and the need for further studies in the region. The results could in fact point to the survivor effect: children that do survive in areas with the highest deposition of dust may develop a greater immunity towards respiratory illnesses, and thus rates of illnesses appear to be lower among "survivors." It has been found that in early

[29]. Desertification is defined by Grainger (1990) as the degradation of lands in dry areas; a subtle, dispersed and continuous process which occurs far from natural deserts and is in essence the conversion of fertile land into desert. Lal (2001) estimated the global rate of desertification to be 5.8million hectares per year.

life, the innate immune system can recognise both the “viable and nonviable parts of micro-organisms”, and immune activation may direct the immune response, thus conferring tolerance to allergens (Braun-Fahrländer et al. 2002). The inverse correlation between exposure and irritants (organic endotoxins in the case of cotton) in children and the prevalence of respiratory symptoms is not uncommon and indicates that environmental exposure to irritants may in fact help to develop tolerance to pollutants in early life (Rylander et al. 1985). Nonetheless, it should also be highlighted that although respiratory illnesses among children in the region are already significantly higher than rates in the rest of Uzbekistan, and that although dust deposition was not positively correlated with the highest rates in the study areas, overall rates continue to be a serious public health concern (O’Hara et al. 2000).

6.3.4.3 Agrochemical exposure

Biologic information on child pesticide exposure is limited; agrochemicals enter children’s bodies by being absorbed through the skin, ingestion in food, water and/or inhalation (Eskenai et al. 1999). It has been found that in rural communities children may have a higher exposure to pesticides than other residents in a household as they are likely to spend more time in the home and thus in proximity to pesticides present in their immediate environment (on clothes, in food) (Silver et al., 1994). Children under the age of one receive their greatest exposure through breast milk or inhalation (Clark et al., 1985). Jensen and Mazhitova (1997) reported on the dangers of breast milk for infant health in the Karakalpak region where post-natal survival can be threatened due to the mother’s ingestion of animal fat and cottonseed oil that contains a high content of pesticides, salts and other chemical additives (Jensen et al. 1997, Hooper et al. 1998, Buckley 2003). A 1993 report to the United States congress emphasised the higher risk children face from pesticide exposure[30]; young children are particularly vulnerable due to the sensitivity of developing organs, combined with a reduced ability to “detoxify” such chemicals (Benke and Murphy, 1975). Health effects of pesticide exposure are most commonly linked to central nervous disorders; implications for chronic or acute pulmonary disorders have likewise been cited (Kirkhorn and Gerry, 2000). The vulnerability of respiratory health effects in children, including the occurrence of childhood asthma have also been cited (Eskensazi, et al., 1999). Asthma has been identified as one of the most common chronic disease of childhood and has been positively associated with exposure to organic dusts and agricultural chemicals (Schwartz, 1999)

[30] National research council. Pesticides in the Diets of Infants and Children. Washington: National Academy Press, 1993

6.3.5 Effects

Inefficient and polluting production methods of cotton are similar throughout Uzbekistan, however, the negative externalities impact more heavily on health where poor ecological and unfavourable socioeconomic conditions are more severe in the country. As introduced in Chapter 4, infectious and respiratory diseases are the principle cause of infant death in Uzbekistan, with rates the highest in the Karakalpak region nearest the Aral Sea (Anderson 1997, WHO 1999, 2003). As discussed in the previous section, there is significant evidence in the literature that respiratory disorders are correlated with increased airborne particulate concentrations. Of particular concern in Uzbekistan, are particulates laced with organic chemicals, microbiologic pathogens and potentially carcinogenic minerals.

National level statistics "mask" important regional variation in morbidity and mortality (WHO 1999). Some reports place infant mortality rates in the Autonomous republic of Karakalpakstan as much as 40% higher than the Uzbekistan regional average, with rates highly correlated with proximity to the Aral Sea (Anderson 1997). Infant mortality nearest the Aral Sea has reportedly increased from 25/ per 1000 live births in 1950 to between 70-100 per 1000 in 1996, with acute respiratory diseases accounting for more than one-half of all child deaths, followed by diarrhoeal disease (Zetterstrom 1999, Small et al. 2001, Whish-Wilson 2002). The World Health Organization recognised in its 2001 Environmental Health Impact Assessment that regional differences in mortality and morbidity among oblasts reflects "in part the concentration of major environmental problems" and that greater attention should be given to the "complex cause-effect relationship" between the health hazards in the region from agriculture (in particular pesticide and fertilizer use), combined with the declining socioeconomic conditions (WHO, 2001, p. 164).

Contamination of water and food with pesticides and salts in Uzbekistan is amongst the worst in the fSU; as a consequence cancer rates are as much as six times higher in the ASB than adjacent regions at the time of dissolution of the USSR (French 1991). Up to 60% of rural Karakalpaks drink from wells dug into salty underground reserves for their water; infants notably refuse their mother's breast milk as it is too salty (Jensen et al. 1997). Nearest the Aral Sea, 97% of women suffer from anaemia with nearly 87% of their offspring classified as anaemic; birth defects and miscarriages are a common result of the illness (Ataniyazova 2003). A study of 433 children in the Muynak district (once on the shore of the Aral Sea), found iron deficiency was positively correlated with household water source where the odds of anaemia were 2.4 times higher for children whose primary household water source was a communal tap (Giebel et al. 1998). No significant association was detected among sex, nationality, birth weight, or diet. Maternal education, socioeconomic status or mother's history of the disease were also not found to be significant in incidence of rates of anaemia on the study site (Giebel et al. 1998). The study provides further evidence of environmental factors playing a key role in determining mortality and morbidity in Uzbekistan. When omitted variables are reduced (such as in small area studies like that of Giebel, et al. 1998), variation in rates of illness point to the impact of environmental determinants and the significant role environmental health plays in determining mortality. In the independent republic of Karakalpakstan a study found one of the highest rates of oesophageal cancer in the world (Zaridze et al. 1992). Although the authors of the study do not suggest environmental health factors in the region explain the high rate of the disease (higher than the rest of the fSU), they do suggest ethnic or geographic factors may be responsible. In fact, the disappearance of the Aral Sea and the known environmental health consequences are not mentioned in the article.[31] Upshur and Crighton (2004) argued the disappearance of the Aral Sea cannot positively explain the high rates found in the Zaridze et al. (1992) study—despite those living nearest the Aral Sea having the highest incidence of the illness. The authors argue rates have declined since 1973, corresponding with the Sea's disappearance (Upshur and Crighton 2004). Nonetheless, it has been argued the link between anaemia, like other non-infectious illnesses, and the environment is "less tenable" due to the distribution of prevalence of the disease; that unless the exposure was primarily at home, the environment could not explain differentials in rates (Upshur and Crighton 2004). The authors found that because rates of anaemia are a problem throughout the whole of Uzbekistan, the findings in the Giebel and Suleymanova et al. (1998) study cannot necessarily be linked to the environmental problems connected to the Aral Sea crisis.

The negative externalities associated with the disappearance of the Sea are not isolated to the ASB only; sand storms high in salt and chemical contents are widespread and inevitably affect water supplies in other parts of the country. Furthermore, pesticide exposure can reduce immunity and increase rates of acquired anaemia and could plausibly explain high rates throughout the rest of Uzbekistan. As has been highlighted by the WHO and others, anaemia is amongst the highest in the world in Karakalpakstan, despite comparatively elevated socioeconomic development when compared with other countries with like income levels (Giebel et al. 1998). A measure for infant deaths related to anaemia, at the oblast level, was not available and thus it was not directly included in the subsequent analysis.

[31] In the authors' defence, the article was published in January of 1992 and commissioned by the Soviet government and, therefore, they may not have been free to suggest a link between the environmental disaster in the region and their exceptional findings.

Data are even scarcer on specific environmental pollutants and their impact on population health in terms of non-infectious diseases; thus the connection between environmental quality and non-infectious diseases more unclear. According to the WHO (1999), deaths from infectious diseases stabilized in the post-Soviet period and, unlike in other CARs, showed no increase in Uzbekistan for the overall population, while circulatory and other non-infectious illnesses have grown. Compared to the rest of the European Union (EU), however, infectious diseases remain a significant threat to health and particularly to infants and children. Official data for Uzbekistan show rates of infant mortality for all oblasts between 1999 and 2003 from respiratory and infectious diseases were not decreasing in all cases (Figure 6.6). Particularly in the poorest oblasts, exogenous causes of mortality (such as respiratory illnesses) continue to exceed endogenous causes (more important during the perinatal period) (see Table 6.8)

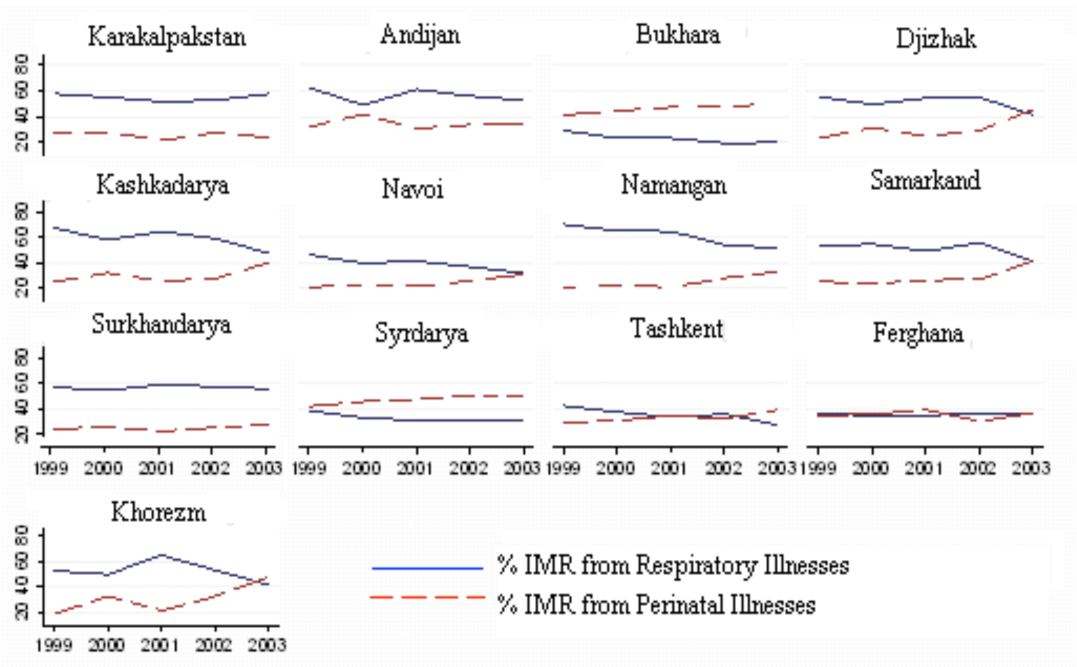


Figure 6.6 Variation in infant mortality: respiratory and perinatal illnesses (1999-2003). Source: Data Appendix C

The severity of the environmental and health problems in Uzbekistan has led to well over 45 NGOs (in 2001) engaged in health-related activities in the country; coordination between them and the government, however, remains limited. Despite the significant recognition of the environmental health concerns in the country, there remains a significant need to further understand the potential sources and health impacts of current policies in the country- particularly in relation to health care services, chemical contamination from agrochemical applications and the long-term health impacts of a population exposed to monoculture cotton and contaminated respirable dust (WHO 2001).

6.4 ANALYTICAL FRAMEWORK

The following section introduces the framework adopted to explore the determinants of variation in infant mortality in Uzbekistan. The dependent and independent variables used in the analysis will then be discussed in Section 6.4. A framework to assess the determinants of mortality was proposed by Mosley and Chen (1984), where the effects of social and economic factors on mortality are estimated via a common set of intermediate variables (Chapter 5).

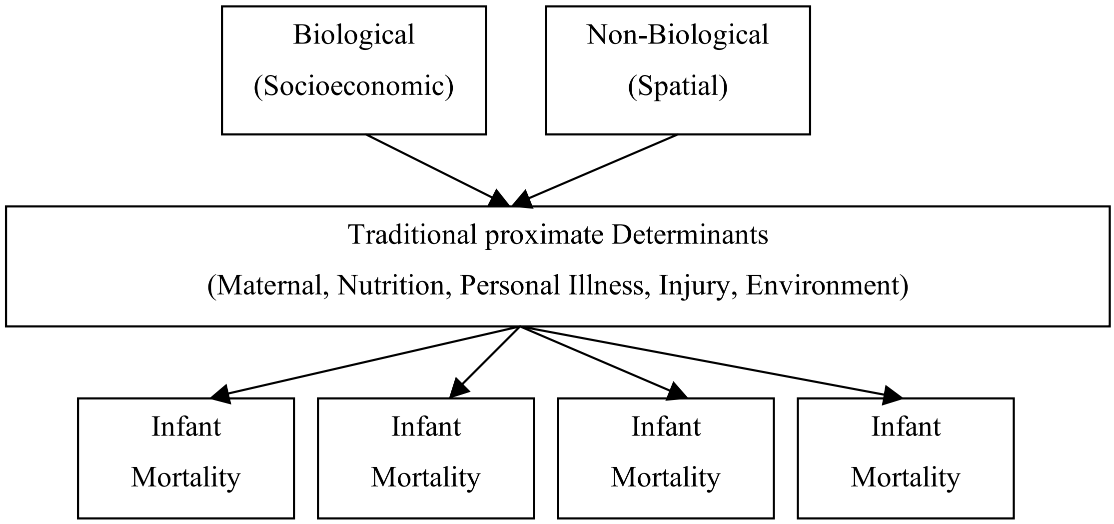


Figure 6.7 Framework of analysis: modified Mosley and Chen (1984). Source: Balk et al. 2004

For the following analysis a modified version of the traditional Mosley & Chen (1984) framework was utilised, as proposed by Balk et al. (2004) and seen in Figure 6.7. This approach expands upon traditional studies by distinguishing between biological mechanisms and variables classified as non-biological, i.e. identifying geographical factors that incorporate natural boundaries and physical information (Balk et al. 2004). Such an approach compliments the environmental contamination variables key to the Mosley & Chen (1984) framework where the transmission through the environment of infectious agents (e.g. water quality) is the main focus. By exploring non-biological factors that incorporate information about geographical boundaries, one can proxy environmental health threats that are not readily measured and thus traditionally excluded from analysis, especially due to the limited data set which lacks direct environmental quality measures. Balk et al. (2004) emphasise "…descriptions of study sites may set the stage for an analysis and assist in the explanation of residual effects" (p. 179). Due to a lack of direct measures of environmental quality, a range of non-biological variables will be used, including density of population in arable areas and land sown to cotton and prevalence of irrigation per rural inhabitant. Additional effects not captured by the traditional and non-biological variables alone will be incorporated by using oblast dummies.

6.5 DATA

The specific aim is to understand variation in infant mortality within Uzbekistan that may be linked to socioeconomic as well as non-biological factors that evidence poor environmental quality in the form of land, water and soil pollution. The next section outlines the variables used in the model to explain variation in mortality among oblasts.

A description of variables used in the final analysis, along with descriptive statistics and simple correlations can be seen in, Table 6.4, 6.5 and 6.6, respectively.[32] Due to limitations in the available dataset, some direct measurements of biological determinants central to infant survival were not included, e.g. nutrition, birth weight, water quality, sanitation and birth order. Household level data are available from the Demographic and Household Surveys (Measure DHS) for Uzbekistan in 1996 and 2002 which show a level of homogeneity in some nutritional variables, including breast feeding and level of anaemia between regions (an indicator of iron deficiency). It will be assumed for the purpose of this study levels of nutrition will not vary greatly among oblasts (particularly between urban and rural groups), although within oblast variation is likely between urban and rural populations (Spoor and Visser 2001). Non-biological information explored in the analysis captures the effects of land use, irrigation and crop type. Traditional determinants were first tested in a general to specific approach. Once the equation for total infant mortality was well-specified, a series of non-biological variables were included, one by one to see the additional explanatory power of the "non-traditional" determinants.

Table 6.4 Description of variables used in final analysis

Variable	Symbol	Description
Infant Mortality	IMRT	Deaths between 0-1 per 1000 Total
Rural Infant Mortality	IMRR	Deaths between 0-1 per 1000 Rural births
Urban Infant Mortality	IMRU	Deaths between 0-1 per 1000 Urban births
Infant Mortality from Perinatal Illnesses	IMRPERI	Cause of infant deaths per 10,000 births due to illnesses originating in the perinatal period (0-7 days)
Infant Mortality Due to Respiratory Illnesses	IMRRI	Cause of infant deaths per 10,000 births due to respiratory illnesses
Income per capita	SOMSPC	Thousand Soms per capita (local currency)
Doctors per capita	DRS	General practitioners per 10,000 of total population
Age-specific birth rate of mother	BR1	Total births rate per 1000 women aged 15-19 (children per woman)
Cropped area sown to cotton	CAC	Share of total cropped area sown to cotton (%)
Cropped area irrigated	CAI	Share of total cropped area under irrigation (%)

[32] A full description, simple correlations and descriptive statistics for all variables explored are listed in Data Appendix B.1-B.2

Table 6.5 Descriptive Statistics of variables used in final analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
IMR	65	18.01	2.63	13.60	24.60
IMRR	65	16.56	2.67	11.70	21.70
IMRU	65	21.84	5.65	14.60	46.00
SOMSPC	65	142.26	96.70	23.20	450.70
BR1	65	18.08	7.24	1.98	43.83
DRS	65	25.34	3.60	19.30	35.50
CAI	65	122.85	39.81	65.94	288.81
CAC	65	40.67	8.33	23.33	54.13

Table 6.6 Simple correlations of variables used in final analysis

	IMR	IMRR	IMRU	IMRRI	IMRPERI	BR1	DRS	SOMSPC	CAI	CAC
IMR	1.00									
IMRR	0.86	1.00								
IMRU	0.69	0.29	1.00							
IMRRI	0.56	0.37	0.50	1.00						
IMRPERI	0.28	0.38	0.09	-0.44	1.00					
BR1	0.74	0.52	0.74	0.60	0.04	1.00				
DRS	-0.20	-0.33	0.15	-0.23	0.12	-0.03	1.00			
SOMSPC	-0.61	-0.57	-0.35	-0.54	-0.06	-0.61	0.23	1.00		
CAI	0.15	-0.02	0.13	0.05	-0.11	-0.07	0.18	0.28	1.00	
CAC	0.21	0.04	0.32	-0.12	0.43	0.27	0.27	0.05	0.23	1.00

6.5.1 Dependent variables

6.5.1.1 Infant Mortality (Total, Rural, Urban)

All health data used within the following study are from the Uzbekistan Ministry of Health (MOH) and descriptive statistics for infant mortality by groupings used within the study can be seen in Table 6.7.[33] Infant mortality data at the oblast level were available for total infant deaths as well as for endogenous and exogenous causes of death. Data were also available disaggregated by rural and urban and male and female for total infant deaths. More specific groupings of mortality by cause of death were not available, e.g. rural male infant deaths or urban deaths from respiratory illnesses. The absence of more complex stratifications reduces the explanatory power of proximate and direct determinants to explain cause of death at the oblast level. Variables capturing infant mortality for all causes of death include total (IMRT), urban (IMRU) and rural (IMRR) infant mortality.

[33] Appendix C includes a source list for all oblast data used within this chapter.

It is expected IMRT will have the highest explanatory power in the estimations as it includes the largest sample of reported deaths. Urban rates are reportedly higher than rural in the oblast dataset, evidencing serious under reporting for rural infant deaths. As discussed in Chapter 4, this discrepancy is due primarily to poor registration and definitional problems. Household data provide evidence rural mortality is significantly higher than urban infant mortality across the country (Buckley, 1998).

Table 6.7 Descriptive statistics for infant mortality variables used (Avg. 1999-2003)

	IMRT		IMRRR		IMRU		IMRPERI		IMRRI	
Oblast	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Republic of Karakalpakstan	20.78	1.86	18.4	1.64	23.8	2.44	5.44	0.23	0.99	0.49
Andijan	15	1.48	12.34	0.68	21.4	3.24	4.52	0.44	0.47	0.11
Bukhara	17.06	1.92	15.4	2.25	22.2	1.177	5.24	0.32	1.21	0.42
Djizhak	16	2.17	15.38	2.42	18.12	2.03	4.4	0.71	0.68	0.22
Kashkadarya	18.1	2.29	17.58	2.29	19.58	2.48	4.58	0.45	0.63	0.14
Navoi	17.06	2.21	14.56	1.72	21.62	3.47	4.32	0.5	1.52	0.36
Namangan	17.94	1.78	14.88	1.51	22.86	3.51	4.56	0.76	1.48	0.31
Samarkand	15.6	1.32	15.26	1.34	17.16	1.62	3.9	0.44	0.84	0.44
Surkhandarya	18.14	2.84	17.44	2.89	21.82	2.62	5.02	0.67	1.17	0.41
Syrdarya	19.24	1.21	19.42	1.68	18.76	1.92	7.98	0.43	0.88	0.24
Tashkent	17.84	2.17	17.68	2.65	18.16	1.41	5.2	0.29	1.65	0.49
Fergana	19.94	1.5	19.16	1.41	21.92	2.5	5.54	0.7	1.67	0.25
Khorezm	21.46	2.89	17.84	1.45	36.54	9.01	4.94	1.05	0.87	0.63
Total	18.01	2.63	16.57	2.67	21.84	5.66	5.05	1.1	1.08	0.52

Source: Data Appendix C

6.5.1.2 Infant mortality (By cause of death)

Five variables were available at the oblast level for infant mortality by cause of death and combined they explain approximately 97% of total infant mortality among oblasts in 2003 (Figure 6.8). The five variables include two endogenous determinants: perinatal illnesses and birth defects; and three exogenous variables: respiratory illness, infectious/parasitic illnesses and death from accidents/poisoning or injuries Table 6.8. Explaining the largest share of infant deaths among oblasts are those deaths attributed to respiratory illnesses (IMRRI) and illnesses originating in the perinatal period (IMRPERI). The prevalence and variance of respiratory deaths within the country will be used as a proxy for environmental threats linked to land degradation from agricultural activities as well as other traditional forms of pollution for the whole population.

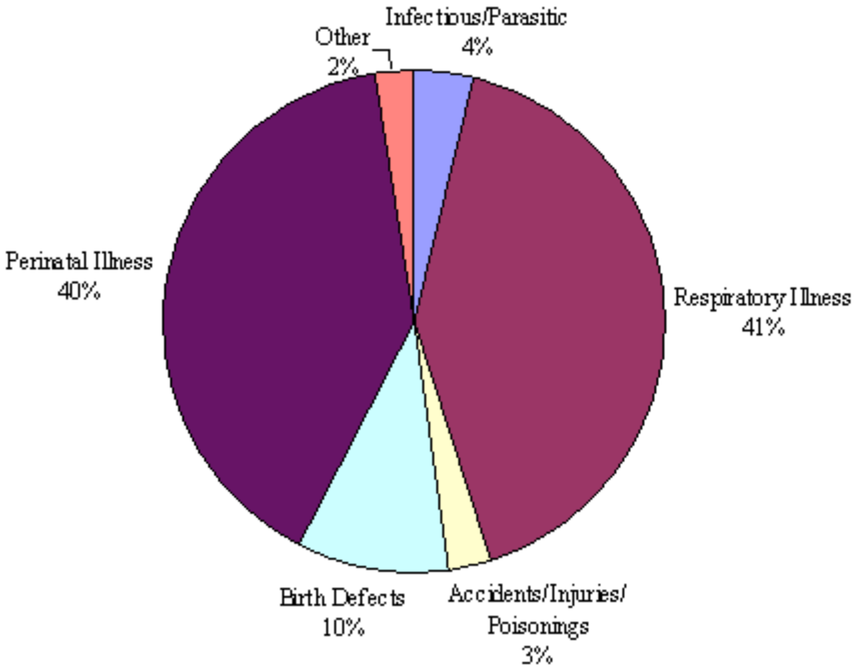


Figure 6.8 Infant mortality by cause of death in Uzbekistan (2003)

Table 6.8 Infant mortality by cause of death, by oblast in 2003

		Exogenous			Endogenous	
Rates per 1000 live births	Total Infant Mortality	Infectious/ Parasitic	Respiratory Illness	Accidents/ Injuries/ Poisonings	Birth Defects	Perinatal Illness
Uzbekistan (total)	16.40	0.66	6.73	0.43	1.59	6.59
Republic of Karakalpakstan	18.30	0.31	10.5	0.34	2.15	4.23
Andijan	13.80	0.43	7.28	0.27	0.84	4.7
Bukhara	14.90	0.64	2.86	0.56	2.79	7.49
Djizhak	13.90	0.44	5.65	0.62	0.53	6.31
Kashkadarya	14.70	0.5	6.97	0.53	0.4	5.91
Navoi	15.70	2.03	4.97	0.33	2.16	4.78
Namangan	15.80	1.02	8.08	0.05	1.38	5.17
Samarkand	13.70	0.34	5.54	0.8	0.91	5.67
Surkhandarya	14.70	0.56	8.18	0.54	0.94	4.09
Syrdarya	17.90	0.86	5.56	0.36	1.57	8.99
Tashkent	15.20	1	4.1	0.48	2.96	5.97
Fergana	20.00	1.28	7.26	0.49	3.53	7.38
Khorezm	18.90	0.34	7.8	0.1	1.48	9.04

Source: Data Appendix C

Average rates of IMRRI were 8.5/1000 for the five year period and the S.D. of 2.8 showed the highest variance out of all causes of infant death. Average IMRRI was highest in Karakalpakstan (11.4/1000), followed by Khorezm (11.3/1000). Rates in these two oblasts were reversed for IMRT, where Khorezm had the highest total infant mortality. IMRRI declined overall for the 5 year period (35%) with the greatest reduction recorded in Tashkent

(53%) and Kashkadarya (50%). In the final period, however, rates were increasing in 4 of 13 oblasts, with the highest increase in Feraghana (8.9%), followed by Syrdarya (1.65%).

Infant mortality from perinatal illnesses is categorized by the International Classification of Diseases (ICD) as conditions originating in the perinatal period (0-7 days), including those which may have their origin in the perinatal period even though death occurs later. The classification excludes malformations, nutritional and metabolic diseases (ICD, 2005). Deaths in the perinatal period are the second most common cause of infant death in Uzbekistan and are considered to be endogenous. For all oblasts in the five year period, mean IMRPERI was 5.69/1000, with the highest average in Syrdarya (9.1/1000) and the lowest mean in Navoi (4.1/1000).

There are significant discrepancies in the IMRPERI data published by the MOH, due mostly to definitional errors associated with live births (see Chapter 4). The majority of infant deaths in Uzbekistan are taking place in the neonatal and post-perinatal period (8-365 days). There is little variation among oblasts for IMRPERI rates, where the S.D. = 1.1 and there is even less variation evident due to lack of urban/rural stratification for the data for IMRPERI. From 1999 to 2003, IMRPERI increased overall for Uzbekistan, and in 7 of the 13 oblasts, rates either stayed the same or increased from 1999 to 2003 with the greatest change in Namangan (42%) for the five-year period.

Infant mortality from infectious/parasitic illnesses (IMRIP), accidents, injuries and poisonings (IMRAIP) and birth defects (IMRBD) were also available; due to the relatively rare occurrence of infant deaths by these classifications, it was decided they would not be estimated in the final analysis.

6.5.2 Explanatory Variables

6.5.2.1 Income

To begin, income and expenditure variables were tested, including income per capita in local currency SOMS (SOMSPC), expenditure per capita (EXP) and savings per capita (SAV). Income is incorporated as a control variable as it operates on social and environmental variables; poorer populations normally reside in rural areas and generally have reduced access to a clean water source, sanitation and other services, such as health care. The importance of income as an explanatory variable in infant survival is well explored in the literature (see Chapter 5 for discussion). A measure of income distribution at the oblast-level was not available.

The reported nominal income used in the analysis is from the Uzbekistan Ministry of Statistics (Data Appendix C). As discussed in 6.2, the highly questionable accounting methods in the country clearly bias the role of income in explaining variation in a multitude of social factors, including access to health care and other goods and services. A deflated value of income was not used as inflation rates for each year were not available. Combined with high inflation, and a lack of information on price levels at the oblast level, it is difficult to know the real spending power of households, as well as variation between rural and urban populations.

There is a significant increase in reported per capita income in the data from 1999 to 2003; income between oblasts for each period shows greater homogeneity. Income varied most significantly out of all other explanatory variables; its explanatory power in the model will arguably be inflated. Time dummies will be introduced to control for the significant changes in this variable between periods.

6.5.2.2 Maternal Factors

In the literature, the most commonly sited variables in determining child survival are maternal factors, including maternal well-being (nutrition, access to health care), maternal education, age and marital status of the mother. These variables are classified by Eberstein (1984) as main and intermediate effects, where main effects include race/ethnicity, education and marital status. Intermediate variables are those said to mediate the effect of socioeconomic, demographic and background of the mother in influencing child survival and include maternal age and prenatal care (Eberstein and Parker 1984). Health care services are likewise noted as a key pathway through which increased maternal education can lead to greater infant survival (Mensch et al. 1996). Likewise, age of marriage is a pathway through which higher maternal education can act on infant survival, i.e. the later one marries the fewer children one has and the higher the survival rates. Within this study, a number of proxy variables for maternal factors important to infant survival will be tested. The share of individuals completing secondary education (EDU) out of all people aged 10-16 (secondary school age in Uzbekistan), will be used as a proxy for education; observations disaggregated by sex or by urban/rural were not available for all time periods. This variable is expected to be negatively correlated with infant mortality. Due to highly homogenous rates of education throughout Uzbekistan, the variable is not expected to be significant in explaining variation in mortality among oblasts.

A comprehensive education profile was conducted by DHS EdData for Uzbekistan (DHS, 2003) and household-level data are available from these surveys for 1996 and 2002.[34] The studies reveal a high rate of education for the whole of the Uzbek population. For example, literacy rates averaged 98% in 2002; among women aged 15-49 literacy was estimated at 99.8% in the same year. Primary school completion in 2002 was 98% for men and 96% for women; secondary school completion for women was 32% in 2002 and 41% for men in the same year (DHS, 2003). Furthermore, children in urban and rural areas were almost equally likely to attend primary school, with no significant difference in male to female attendance between urban and rural areas. Attendance was slightly higher among the female rural population (vs. male rural) in 2002, with 89% and 86% in attendance, respectively. There are some regional differences, however in the Net Attendance Ratio (NAR) for primary school age pupils.[35] The lowest NAR was found to be in the Western Region, with 84.4% in 2002 for the total population and 83% for females; the highest NAR was in the Central Region averaging 93% for both male and females in 2002 (DHS, 2003).

An additional maternal variable will be tested: age-specific birth rate of the mother (BR) (Table 6.12). This variable is disaggregated by five age groups (Data Appendix B.1). On the one end of the spectrum, mothers aged 15-19 (BR1) will be explored, where younger mothers are likely to be less capable of ensuring the survival of their infants due to lack of resources and/or lower levels of education (See Table 6.12). At the other end of the spectrum is a measure of mothers aged 35-40 (BR5). Older mothers experience higher rates of infant death as complications with pregnancies are more common. Age of the mother at time of giving birth will control for a number of factors, including education, income level (as younger mothers are poorer), access to birth control as well as total fertility, for which direct measures were unavailable. Younger mothers have fewer children and the relationship between age of the mother and fertility is inversely correlated (Data Appendix B.2). The total fertility rate (TFR) will not be used in the analysis due to problems of reverse causality. Age of the mother at birth will proxy for the TFR and, as seen in Table 6.9, there is relatively small variation in TFR among oblasts.

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[34] The 1996 survey was administered to 3,703 households and to 4,415 women aged 15-49 from those households. The 2002 survey was administered to 4,168 households, 5,463 women age 15-49 and 2,333 men age 15-59.

[35] Net Attendance Ratio (NAR) is equal to the number of students of primary school age attending primary school/number of people of primary school age in the total population (age 6-9 in Uzbekistan). (Demographic Health Survey, 2003).

Table 6.9 Variation in the total fertility rate (TFR) by oblast (1999-2003)

Oblast (Ref.#)	Mean	Std. Dev.
Karakalpakstan (1)	2.63	0.20
Andijan (2)	2.35	0.14
Bukharan (3)	2.26	0.07
Dzhizak (4)	3.07	0.17
Kashkadarya (5)	3.17	0.25
Navoi (6)	2.29	0.06
Namangan (7)	2.49	0.16
Samarkand (8)	2.88	0.21
Surhandarya (9)	3.13	0.22
Syrdarya (10)	2.71	0.14
Tashkent (11)	2.29	0.07
Ferghana (12)	2.31	0.12
Khorezm (13)	2.53	0.20
Total	2.62	0.36

6.5.2.3 Nutrition

Nutrition is a key factor of infant survival. Low birth weight and stunting are variables often used to indicate poor nutrition, especially in children aged 1-4. Growth faltering (malnutrition) serves as a measure of relative risk, but is not valid to relate specific absolute levels of mortality across populations due to significant variation among countries and the risk of dying attributable to different causes between countries and populations (Mosley and Chen 1984). Deficiencies in key nutrients have been examined in connection to malnutrition in infants and children in the CARs and found to vary based on location in the country, among other factors such as ethnicity (Buckley, 2003). Maternal nutrition acts directly on the nutritional status of infants through breastfeeding. Data on breastfeeding between 0-3 months and 0-6 months were available at the oblast level. However, the data are available as a share of infants in the same age group who survived; therefore, it is not possible to differentiate between breastfed and non-breastfed infants.

Birth weight and prenatal care are strongly associated with infant survival (Mosley and Chen 1984, Cramer 1987, Blum and Monnier 1989, Carlson and Bernstam 1990). A control variable for nutrition in explaining infant survival at the oblast level was not available. Variation for the variable IMRPERI may indicate deaths due to poor nutrition. Infant deaths due to under-weight usually originate within the first seven days. Birth weight of the infant is often used as a proxy for nutrition and an indicator of an infant's chance at survival as early term births or under-weight births have a lower chance of survival. Therefore, by exploring IMRPERI as a dependent variable, we are indirectly assessing the role of nutrition in explaining variation in mortality in the country.

6.5.2.4 Personal illness

Within the proximate determinants framework proposed by Mosley-Chen (1984), personal illness refers to proximate determinants that capture access to services of preventative care, e.g. immunizations or antenatal care. Within our analysis, access to health care and services will be used to proxy for personal illness or the ability of mothers to provide preventative care for infants. As a determinant of infant survival, access to health care professionals and services is widely explored in the literature; variation is most common between urban and rural populations and especially in the poorest countries (Chapter 2). Data on health care facilities and providers is not disaggregated by urban and rural populations at the oblast level. Within this study, a number of variables were tested to capture access to and prevalence of health care facilities and practitioners by oblast. There is a wide range of data available covering health care prevalence as is shown in Data Appendix B.3. After some exploration of significance in cross-correlations, the variables tested included BEDS1, BEDS2, DRS, DAY DAY2 OUT POLY PAT HOMPAT, and GBEDS. Also explored in the analysis was the number of health centres per female of child bearing age (16-39); this variable (MATCENT) was used to proxy for maternal access to health care facilities.

6.5.2.5 Injury

According to the ICD, poisonings and injuries include injuries to any part of the body, burns, poisoning by biological substances and/or drugs. The category excludes birth and obstetric trauma. Infant mortality data due to accidents, injuries, poisoning (IMRAIP) are available. However, due to the relatively small number of deaths included in this category, as well as insufficient explanatory variables addressing these specific threats, IMRAIP was not included in the final analysis. Differentials in this variable among oblasts are shown for expositional purposes in Table 6.10. Alternative variables for this category were not available.

Table 6.10 Variation in infant mortality accidents/injury and poisoning (IMRAIP) (1999-2003)

Oblast (Ref#)	Mean Std.	Dev.
Karakalpakstan (1)	0.33	0.14
Andijan (2)	0.33	0.08
Bukharan (3)	0.55	0.17
Dzhizak (4)	0.89	0.35
Kashkadarya (5)	0.42	0.11
Navoi (6)	0.59	0.28
Namangan (7)	0.21	0.10
Samarkand (8)	1.07	0.31
Surhandarya (9)	0.71	0.21
Syrdarya (10)	0.31	0.10
Tashkent (11)	0.51	0.15
Ferghana (12)	0.52	0.06
Khorezm (13)	0.09	0.03
Total	0.50	0.31

6.5.2.6 Environmental and non-biological determinants

This category is concerned with environmental routes of infection or transmission, including air, water, food and soil. Within the Mosley-Chen (1984) framework, such variables capture environmental conditions that cannot be (readily) influenced by the family's behaviour, e.g. proximity to pollution, rates of exposure, and consumption of contaminated water and food stuffs. The most widely tested environmental health indicators are access to clean water and sanitation. Such variables are often used to explain variation in health outcomes linked to specific morbidity, e.g. diarrhoeal diseases (Esrey SA 1991, Pruss 2002). The literature on determinants of mortality has supported a strong inverse correlation between access to water, improved sanitation and child survival (Schultz 1980). In a multivariate analysis, however, the explanatory power of these variables has been questionable when other socioeconomic variables are included; the indirect link between poor water quality and sanitation and the end result of mortality makes detecting the relationship between the two difficult (Chapter 5). Omitted variable bias arguably confounds the power of environmental variables to explain variation in mortality due to indirect contamination routes, and they are more widely used in analysis of disease-specific morbidity (Murray 1997, Buckley 2003).

Pathways of infection for this group of intermediate variables are less well defined and understood; identifying and measuring environmental factors that may transmit diseases is less precise and often much costlier than measuring and quantifying socioeconomic factors. Available data on water *quantity* is more widely available; water *quality*, on the other hand, is more difficult to measure and may not be immediately visible. Proxy variables that capture exposure to a polluted water source include diarrhoeal disease and dysentery (as faecal water pollution is a widespread problem and a leading cause of death among infants). Although not available disaggregated by age group, incidence of dysentery for the entire population varies significantly among oblasts as seen in Table 6.11. Rates in Karakalpakstan are 4.7 standard deviations from the mean for the rest of the country. In Tashkent, however, rates were 12 standard deviations from the mean, despite better access to improved water and sanitation. This oblast has one of the largest urban populations and is also the most economically developed (Data Appendix A.3). This points to significant under reporting for rural regions, where water quality and accessibility is much lower.

Table 6.11 Variation in incidence rate of dysentery (per 100,000) by oblast (1999-2003)

Oblast (Ref.#)	Mean Std.	Dev.
Karakalpakstan (1)	22.24	4.70
Andijan (2)	6.89	2.89
Bukharan (3)	6.74	4.01
Dzhizak (4)	16.83	2.49
Kashkadarya (5)	6.86	2.95
Navoi (6)	20.28	10.47
Namangan (7)	18.17	8.74
Samarkand (8)	3.20	0.66
Surhandarya (9)	7.79	2.88
Syrdarya (10)	10.76	5.39
Tashkent (11)	49.86	12.06
Ferghana (12)	39.57	11.13
Khorezm (13)	4.68	1.27
Total	16.45	14.91

There is a dearth of measures of environmental quality at the oblast level, therefore, the following analysis will use non-biological variables to operate as environmental (intermediate) determinants. For example, the share of cropped area irrigated or sown to cotton indicate prevalence of poor water availability or poor water quality. The greater the share of irrigated area or prevalence of cotton, the less water available for human consumption as agriculture and human consumption compete for limited resources. Likewise, populations living in areas where cotton production is more prevalent have higher exposure to chemical residuals, lower access to potable water, and arguably greater potential for exposure to degraded lands resulting from long term production of monoculture cotton. It is expected, therefore, infectious and parasitic illnesses associated with poor water quality and availability would be higher in areas with more widespread irrigation and cotton monoculture; that respiratory illnesses and other socioeconomic factors related to cotton production operating on environmental factors will increase various kinds of chemical exposure. Therefore, explored in the analysis were irrigated area per rural inhabitant (IRRIG),[36] the share of total cropped area under irrigation (CAI), share of arable area sown to cotton per rural inhabitant (CTTNPC), and the share of total cropped area sown to cotton (CAC). There has been a significant shift away from cotton towards wheat production and rice production (grains), therefore, a measure for the share of total cropped area sown to grains was also tested (CAG). Likewise explored in the estimations were the number of *shirkat* farms (collective farms) sown to cotton (CTTNSH); the share of cotton out of total agricultural output (CTTNSHR) and the share of total agricultural area that is arable per rural inhabitant (ARABPC).

6.6 EMPIRICAL METHODOLOGY

The following study is a longitudinal ecological analysis using secondary, unmixed data to explain variation in infant survival at the oblast level within Uzbekistan. By utilizing data at this level, much omitted variable bias present in a cross-national study can be avoided. It is recognised that the grouping of observations inevitably presents problems of unobserved characteristics being correlated across the sample, thus reducing the efficiency of the estimated coefficients (Guo and Rodriguez 1992). Since there are several observations for each oblast, one can adjust the standard errors for intra-oblast correlation in the error terms by using a cluster option in Stata. This option was used to conserve valuable degrees of freedom. Heteroscedasticity is not corrected with this type of estimation and it was assumed there is none (Wooldridge 2002).

In the literature, infant mortality is modelled either as a continuous variable (as discussed in Chapter 5) or it can be modelled as a binary response variable, i.e. death or survival. Binary or logistic regression is a form of regression used when the dependent variable is a dichotomy.

In the logistic regression, or logit, a vector of explanatory variables is used to predict the dependent variable, and to determine the percent of variance in the dependent variable, explained by the independents. The logit family of models is recognised as the essential "toolkit" for studying such binary variables (Greene 2003), and logistic regression is extensively used in the medical and social sciences (Agresti, 2002). Coefficients in this model were computed using a maximum likelihood estimation (MLE) which requires the *blogit* command in Stata (StataCorp, 2005).

[36] Irrigated area by oblast was available for 3 observations only (see Data Appendix B.3) and, therefore, two additional observations were estimated based on previous years. Irrigated area does not change significantly from year to year and therefore the estimations were felt to be an accurate representation of irrigated area by oblast for use in the analysis.

In the following analysis, the dependent variable, infant mortality, is modelled as p_{it}, and is the proportion of infants dying in oblast i in period t where $0 \le p_{it} \le 1$. The transformation of the logit used within this analysis can be formalised as:

$$Y_{it} = \ln\left(\frac{p_{it}}{1 - p_{it}}\right) \qquad [1]$$

where the value of Y_{it} can be any real number between $-\infty < Y_{it} < \infty$.

In this chapter, a regression was undertaken of Y_{it} on a vector of k explanatory variables using the following equation:

$$Y_{it} = \alpha + \beta_1 x_{1it} + \beta_2 x_{2it} + \ldots + \beta_k x_{kit} \qquad [2]$$

For the logit, the estimated coefficients do not have a direct and clear interpretation. If the *j-th* explanatory variable is a continuous variable, and because infant mortality is a statistically rare event and thus typically close to zero, the following approximation can be used:

$$\beta_j \approx \frac{1}{p} \cdot \frac{\partial p}{\partial x_j} = \frac{\partial \ln(p)}{\partial x_j} \qquad [3]$$

Due to the difficulty in interpreting the estimated coefficients in this type of model, a preferred reporting method is that of the marginal effects and elasticities. In Stata, the marginal effects or elasticities are calculated at the mean of the independent variables. Elasticities are reported for all estimations in Section 6.7 and, for the continuous explanatory variables, the reported coefficients can be interpreted as the percentage change in the probability of dying as an infant (Y) due to a 1% change in the explanatory variable (X). The marginal effects are estimated as d(ln$Y$)/d(ln$X$) .

Special treatment is required when evaluating elasticities and marginal effects when the explanatory variables are discrete, such as is the case with the regional dummy variables used in the following analysis. The regional dummies take the value of either 0 or 1 and the marginal effects are estimated as the d(ln$Y$)/dX). Therefore, based on the results in Table 6.14, one can interpret the results as there being a higher probability of dying in the Western (control) region, than in the other regions, all else being equal.

An additional interpretation of the results reported in Table 6.14 (1B) could take the following form: the coefficient of -0.16 for the East-Central region indicates that compared to the Western (control) region, the infant mortality rate in the East-Central region is 16% lower. Based on the mean value of infant mortality in the Western region of 21.1/1000, the probability of dying in the East-Central region is, therefore, 0.84*21/1000=17.64/1000 *or* 1.764%. The results from the model indicate, therefore, that the probability of survival is 100*((979-982.36)/982.36) =-0.342 *or* 0.342% lower in the Western region than in the East-Central region; therefore, the probability of survival in the Western region is (1-(21/1000))=979/1000 *or* 97.9% and the probability of survival in the East-Central region is (1-(17.64/1000)=982.36/1000 *or* 98.3%, all else being equal.

6.7 RESULTS

The model was estimated using Stata V. 9 (StataCorp 2005). A balanced panel for the 13 oblasts for the period 1999-2003, totalling 65 observations, was estimated. Separate equations for total, urban and rural infant mortality, as well as mortality by respiratory and perinatal illnesses were specified. A series of explanatory variables were tested (as discussed in Section 6.5 above) for IMRT to begin; the same explanatory variables were then used for all other estimations to allow for comparison among dependent variables. The model was specified in two stages. The first stage looked at the traditional determinants common to the literature to explore their explanatory power. Once the equations were well specified, i.e. the traditional explanatory variables were significant, non-biological variables were included to explore additional variation among oblasts not captured by the traditional determinants alone. Regional dummy variables were then incorporated to examine variation among geographic regions that may not be captured by the socioeconomic and non-biological variables alone. The reference (or control) region for all estimations was the Western region.

To control for inter-temporal variation in explaining infant mortality, time dummies were also tested in the final analysis and found to be collinear with the income variable. Time dummies were therefore included separately from the income variable and the results are reported in Table 6.15. The year 1999 was used as the reference region and the results are interpreted against this year.

Table 6.12 Variation in significant socioeconomic variables, by oblast (Avg. 1999-2003)

	BR1			DRS			SOMSPC		
Oblast (Ref.#)	Mean	Std. Dev.	Coefficient. of Variation	Mean	Std. Dev.	Coefficient. of Variation	Mean	Std. Dev.	Coefficient. of Variation
Karakalpakstan (1)	16.96	4.08	0.24	25.80	1.48	0.06	97.78	60.40	0.62
Andijan (2)	14.50	4.87	0.34	27.46	1.65	0.06	178.10	117.74	0.66
Bukhara (3)	17.89	3.62	0.20	31.92	3.27	0.10	156.12	104.65	0.67
Dzhizak (4)	12.94	9.52	0.74	20.56	0.88	0.04	110.96	76.27	0.69
Kashkadarya (5)	20.21	6.76	0.33	23.86	1.14	0.05	132.80	88.81	0.67
Navoi (6)	15.75	4.67	0.30	23.78	5.46	0.23	230.70	171.84	0.74
Namangan (7)	23.58	5.14	0.22	25.22	1.35	0.05	116.28	75.67	0.65
Samarkand (8)	11.86	3.01	0.25	29.86	0.93	0.03	122.60	76.43	0.62
Surhandarya (9)	20.66	7.69	0.37	22.62	0.88	0.04	121.92	85.96	0.71
Syrdarya (10)	16.25	4.05	0.25	23.76	0.74	0.03	122.78	77.37	0.63
Tashkent (11)	16.67	5.60	0.34	22.96	0.93	0.04	171.20	124.99	0.73
Ferghana (12)	17.72	5.39	0.30	23.40	0.68	0.03	170.26	107.29	0.63
Khorezm (13)	30.12	10.45	0.35	28.18	0.53	0.02	117.94	73.06	0.62
Total	18.08	7.24	0.40	25.34	3.60	0.14	142.26	96.70	0.68

Table 6.13 Variation in non-biological variables, by oblast (Avg. 1999-2003)

	CAI			CAC		
Oblast (Ref.#)	Mean	Std. Dev.	Coefficient of Variation	Mean	Std. Dev.	Coefficient of Variation
Karakalpakstan (1)	202.20	74.11	0.37	39.13	5.87	0.15
Andijan (2)	115.26	2.91	0.03	46.87	0.75	0.02
Bukharan (3)	115.65	17.21	0.15	53.79	0.66	0.01
Dzhizak (4)	79.82	10.77	0.13	28.51	4.39	0.15
Kashkadarya (5)	101.82	9.34	0.09	35.21	2.54	0.07
Navoi (6)	170.94	66.89	0.39	41.15	2.14	0.05
Namangan (7)	125.73	3.59	0.03	44.30	1.07	0.02
Samarkand (8)	100.16	8.72	0.09	27.19	3.67	0.14
Surhandarya (9)	116.57	2.46	0.02	43.20	1.23	0.03
Syrdarya (10)	114.86	2.76	0.02	50.48	3.29	0.07
Tashkent (11)	112.09	1.72	0.02	31.75	0.70	0.02
Ferghana (12)	120.48	2.77	0.02	41.09	1.49	0.04
Khorezm (13)	121.47	7.97	0.07	45.99	4.23	0.09
Total	122.85	39.81	0.32	40.67	8.33	0.20

6.7.1 Total Infant Mortality (IMRT)

Oblast-level variation in the socioeconomic and non-biological variables that remained significant is shown in Table 6.12 and Table 6.13, respectively. The elasticities of the marginal effects for IMRT are reported in Table 6.14. Only significant variables are reported. The model was estimated in a general to specific approach and to begin the standard variables were introduced and deleted where insignificant. As seen in (1A) and (1B), all socioeconomic variables are significant at the 10% level. The income variable is significant and has the expected sign, although the explanatory power of this variable is the lowest out of all other independent variables in the final estimations. The significant increase in reported nominal income between 1999 and 2003 is arguably inflating the explanatory power of this coefficient in the estimations. However, income is used as control variable and does not affect the significance of the other variables of interest as can be seen in Table 6.15. The other explanatory variables, including CAI, remain significant at the same level or higher when time dummies are used in place of income in the estimations.[37] The BR1 variable has the greatest explanatory power with a 1% increase in the birth rates of mothers aged 15-19 leading to a .2% increase in total infant mortality (or approximately .04 deaths per 1000 live births at the sample mean). As reported in Table 6.17, BR1 varied significantly among regional groupings with the highest rates in the Western region. When the regional dummies were included (1B), the socioeconomic variables all remained significant and the coefficient for DRS increased, indicating a 1% change in the number of general practitioners per capita would lead to a .3% decrease in infant mortality. The regional dummies were significant and negative signed, indicating the probability of dying as an infant is lower in the other regions, than in the Western, (control), region.

The only non-biological variable which remained significant for IMRT was the share of cropped area irrigated (CAI). All other non-biological variables were tried and found to be insignificant in the model. As seen in (1C), the CAI is highly significant with a 1% change in the share of cropped area irrigated in a given oblast, the probability of an infant dying increases by .15%. All the socioeconomic variables remained significant at the 10% level with similarly high explanatory power to (1A). In (1D), we see a share of the explanatory power of CAI is picked up with the regional dummies, but it remains significant at the 10% level as do all other explanatory variables in the model. As reported in Table 6.16, IMRT for the Western region was higher for all years in the analysis. Out of the 4 equations estimated for IMRT, the log pseudolikelihood indicates (1D) is the best specified.

[37] Similar results were found with IMRR, IMRU and IMRRI when the time dummies were included in place of income; the results are not reported.

Table 6.14 Results for total infant mortality (IMRT)

IMRT (Total)	1A	1B	1C	1D
N=65				
SOMSPC	-0.05*	-0.07***	-0.07**	-0.06**
	-1.63	**-2.39**	**-2.05**	**-2.43**
BR1	0.21***	0.15***	0.20*	0.17***
	5.02	**3.69**	**4.89**	**3.89**
DRS	-0.20*	-0.30**	-0.22**	-0.28***
	-1.66	**-2.46**	**-2.14**	**-2.46**
CAI			0.15***	0.09***
			8.37	**2.82**
Western (Reference)				
Central		-0.15***		-0.11***
		-5.83		**-4.13**
East-Central		-0.16***		-0.11***
		-5.19		**-3.07**
East		-0.13***		-0.10**
		-2.50		**-1.95**
Log pseudolikelihood	-221550.16	-221498.14	-221546.89	-221489.36

Note: z-stat in bold. Sig .01=*** Sig.05=** Sig..10=*;

Table 6.15 Total infant mortality rate (IMRT) controlling for inter-temporal variation

IMRT	1E	1F	1G	1H
BR1	0.20***	0.11***	0.19***	0.13***
	4.55	**2.95**	**3.88**	**3.00**
DRS	-0.19	-0.30**	-0.22**	-0.29**
	-1.58	**-2.41**	**-2.12**	**-2.48**
CAI			0.16***	0.07**
			4.73	**2.41**
TIME DUMMIES				
1999 (Reference)				
2000	-0.04	-0.06***	-0.05*	-0.06***
	-1.62	**-2.96**	**-1.83**	**-2.71**
2001	-0.04	-0.08***	-0.07**	-0.09***
	-1.61	**-3.70**	**-2.29**	**-3.95**
2002	-0.09*	-0.12***	-0.11***	-0.13***
	-2.62	**-4.78**	**-2.84**	**-4.74**
2003	-0.11**	-0.17***	-0.13**	-0.16***
	-1.97	**-4.08**	**-2.20**	**-3.63**
REGIONAL DUMMIES				
Western (Reference)				
Central		-0.17***		-0.14***
		-8.32		**-5.20**
East-Central		-0.19***		-0.14***
		-6.78		**-4.01**
East		-0.16***		-0.13***
		-3.29		**-2.85**
Log pseudolikelihood	-221471.74	-221477.62	-221502.2	-221473.74

Note: z-stat in bold. Sig .01=*** Sig.05=** Sig.10=*

Table 6.16 Dependent variables by regional grouping (1999-2003)

	East	East-Central	Central	Western
IMRT				
1999	20.12	18.82	20.27	23.72
2000	17.85	17.57	19.46	22.42
2001	17.75	16.82	18.39	21.16
2002	16.32	15.73	16	19.61
2003	16.79	14.61	14.85	18.59
IMRR				
1999	17.6	18.91	19.41	19.91
2000	15.38	17.09	18.55	19
2001	16.38	16.36	17.41	17.88
2002	14.95	15.25	15.22	16.53
2003	14.94	14.01	13.66	17.07
IMRU				
1999	25.83	18.66	23.49	31.7
2000	23.5	19.1	22.72	29.46
2001	20.67	18.28	21.08	28.07
2002	19.35	17.06	18.86	26.23
2003	21.18	16.43	19.02	21.8
IMRRI				
1999	10.8	9.1	11.17	13.04
2000	8.54	7.95	9.4	11.7
2001	9	7.25	9.5	12.15
2002	7.65	7.22	7.77	10.35
2003	7.51	5.1	6.27	9.2

Table 6.17 Explanatory variables by regional groupings

	East	East-Central	Central	Western
BR1*				
1999	26.79	14.79	20.09	45.48
2000	25.19	12.87	17.99	37.51
2001	19.96	11.39	14.34	33.78
2002	17.98	11.21	11.4	27.97
2003	14.7	9.21	10.16	20.81
DRS				
1999	25.13	25.55	24.66	27.18
2000	24.52	25.13	24.16	26.62
2001	24.1	24.31	23.5	25.68
2002	27.16	26.78	27.95	28.47
2003	25.22	25.56	26.51	26.63
SOMSPC				
1999	36.49	31.28	32.33	26.75
2000	58.48	50.42	51.97	46.53
2001	211.16	162	172.53	136.29
2002	240.51	212.93	227.86	154.98
2003	254.76	243.52	265.81	179.03
CAC				
1999	44.94	31.92	39.8	38.86
2000	42.91	31.89	42.08	40.24
2001	44.66	36.52	44.13	50.21
2002	43.62	34.6	42.49	44.98
2003	43	30.34	40.14	37.42
CAI				
1999	118.64	93.27	108.23	119.06
2000	119.68	96.26	112.54	137.53
2001	120.32	108.17	115.89	201.9
2002	121.44	104.53	119.67	190.8
2003	121.98	98.32	117.12	152.04

**Note*: Estimated value weighted by total female population due to missing data for female population age 15-19 by oblast

6.7.2 Rural Infant mortality (IMRR)

The results for rural infant mortality are shown in Table 6.18. The elasticities of the marginal effects are reported. The socioeconomic variables significant in (1A) were used to allow for comparison among dependent variables. Similarly, a range of non-biological indicators were then tested for significance in explaining variation in rural mortality. Like for IMRT, the socioeconomic variables were all significant at the 10% level and for IMRR, the DRS variable had the highest elasticity indicating a 1% change in general practitioners per capita would lead to a .38% decrease in rural infant mortality or just over .06 deaths per 1000 live rural births at the sample mean. The variable DRS does not show significant variation among oblasts, compared to the other explanatory variables and rates by regional grouping do not vary significantly between years (Table 6.17). However, it is interesting to note the Western region has amongst the highest per capita share of general practitioners in the country, and the two oblasts (Karakalpakstan and Khorezm) show only slight variation from the sample mean (Table 6.12). With the inclusion of regional dummies in (2B), the socioeconomic variables remained significant. Apart from the Central region which was just significant at the 10% level, all other regional dummies were insignificant. In (2C), a range of non-biological variables were tested and once again only CAI was found to be significant at the 10% level. DRS and BR1 once again had the highest elasticity; income was significant at the 1% level although, like for (2A) and (2B), the magnitude of the coefficient was relatively small in the model. As seen in Table 6.16, IMRR is higher in the Western region than the other regional groupings for the five year period. Therefore, the insignificance of the dummy variables in (2D) suggests the fundamental and non-biological variables are explaining the majority of variation in IMRR. CAI became insignificant with the inclusion of the dummies, as variation among oblasts for CAI is being picked up by the dummies. Based on the log pseudolikelihood, (2D) is the best specified of the 4 equations.

Table 6.18 Results for rural infant mortality (IMRR)

IMRR	2A	2B	2C	2D
N=65				
SOMSPC	-0.08***	-0.07**	-0.09***	-0.07**
	-2.21	**-2.12**	**-2.45**	**-2.16**
BR1	0.12**	0.12**	0.11**	0.13**
	2.21	**1.86**	**2.14**	**1.97**
DRS	-0.38***	-0.43***	-0.39***	-0.42***
	-2.58	**-2.53**	**-2.70**	**-2.56**
CAI			0.08***	0.08
			2.70	**1.38**
Western (Reference)				
Central		-0.06*		-0.03
		-1.69		**-0.67**
East-Central		-0.04		0.00
		-.96		**0.00**
East		-0.10		-0.07
		-1.02		**-0.74**
Log pseudolikelihood	-152879.91	-152865.45	-152874.44	-152861.74

Note: z-stat in bold. Sig .01=*** Sig.05=** Sig.10=*

6.7.3 Urban Infant Mortality (IMRU)

The results for IMRU are shown in Table 6.19. IMRU captures deaths from the smallest share of the Uzbek population (approximately 30% of overall population is urban). Reporting in urban areas is better than rural parts of the country which is seen in the higher rate of IMR for the urban population than for rural, figures that are contradicted by household level data. As seen in (3A), only the BR1 variable was significant at the 10% level with a high elasticity. For (3D) to (3G), a series of non-biological variables were tested and both the share of cropped area irrigated (CAI) and share sown to cotton (CAC) were significant at the 10% level. The CAI measure lost significance in (3D), indicating the regional dummies are picking up explanatory power of this variable. Water pollution from industry and poor sewage directly affects urban populations and may be evident in the significant dummy variables in (3B), even after controlling for other socioeconomic determinants. CAC remained significant with the inclusion of the regional dummies in (3G) and SOMSPC and DRS were insignificant in all equations. Based on the results in Table 6.19, the probability of survival is lower in the Western region, than the other regions, all else being equal.

Table 6.19 Results for urban infant mortality (IMRU)

IMRU	3A	3B	3C	3D	3F	3G
N=65						
SOMSPC	0.00	-0.01	-0.01	0.00	-0.02	-0.01
	0.10	**-0.08**	**-0.15**	**-0.06**	**-0.34**	**-0.24**
BR1	0.42***	0.33***	0.43***	0.32***	0.37***	0.31***
	3.61	**3.51**	**3.61**	**3.51**	**2.47**	**3.25**
DRS	0.30	0.14	0.27	0.13	0.21	0.08
	1.45	**1.21**	**1.44**	**1.20**	**1.11**	**0.85**
CAI			0.16***	-0.02		
			5.28	**-0.28**		
CAC					0.26**	0.18**
					2.13	**2.27**
Western (Reference)						
Central		-0.23***		-0.23***		-0.23***
		-3.33		**-2.67**		**-4.01**
East-Central		-0.30***		-0.31***		-0.27***
		-5.12		**-3.36**		**-4.13**
Eastern		-0.17***		-0.18**		-0.19***
		-2.84		**-2.16**		**-3.46**
Log pseudolikelihood	-67935.66	-67872.52	-67914.523	-67872.38	-67921.99	-67868.05

Note: z-stat in bold. Sig .01=*** Sig.05=** Sig.10=*

6.7.4 Infant mortality from respiratory illness (IMRRI)

Results for IMR from respiratory illnesses (IMRRI) are reported in Table 6.20. With this specification the model is not used to explain cause of respiratory illness among oblasts. Instead, the purpose is to identify variation in rates among oblasts that may be due to socioeconomic and environmental determinants. For (4A), the measure of income and BR1 are both highly significant and have the expected sign. With the inclusion of regional dummies in (4B), the magnitude of the BR1 coefficient is reduced, but remains significant at the 10% level. The Central region is the only dummy which is not significantly different from the Western region. As seen in Table 6.16, apart from 2003, the Central and Western regions had the highest rates of IMRRI. In (4C), a series of non-biological variables were tested and only the share of cropped area irrigated was significant and it did not change the explanatory power of the socioeconomic variables. Once the regional dummies were included in (4D), however, only the income variable remained significant and the dummy variables captured all remaining explanatory power in the model. Based on the results in 4D, there is a lower probability of survival in the Western region than in the East and East-Central region, all else being equal. The East-Central region had the lowest rate of IMRRI for all years as shown in Table 6.16. Based on the log pseudolikelihood, (4C) was the best specified of the 4 equations.

Table 6.20 Results for infant mortality from respiratory illnesses (IMRRI)

IMRRI	4A	4B	4C	4D
N=65				
SOMSPC	-0.16***	-0.21***	-0.17***	-0.21***
	-2.69	**-3.83**	**-2.74**	**-3.90**
BR1	0.28***	0.11*	0.27***	0.10
	3.50	**1.63**	**3.21**	**1.41**
DRS	-0.32	-0.48	-0.35	-0.48
	-0.65	**-0.83**	**-0.70**	**-0.84**
CAI			0.18**	-0.04
			2.34	**-0.50**
Western (Reference)				
Central		-0.22		-0.23*
		-1.38		**-1.46**
East-Central		-0.36***		-0.39***
		-3.88		**-3.37**
East		-0.20*		-0.21**
		-1.86		**-1.81**
Log pseudolikelihood	-122892.07	-122786.32	-122863.51	-122785.46

Note: z-stat in bold. Sig .01=*** Sig.05=** Sig.10=*

6.7.5 Infant mortality from perinatal illness (IMRPERI)

The explanatory variables for IMRPERI were all insignificant apart from the CAC—a result that could not be theoretically explained. The results are not reported here. This variable captured a very small share of the overall infant population at risk of dying in the CARs and, therefore, the results were not unexpected. Furthermore, based on definition and reporting problems for this age group (Chapter 4), the underestimated values are further limiting any explanatory power the independent variables may otherwise have.

6.8 DISCUSSION

The purpose of this study was to test the hypothesis that variation in infant mortality at the regional level in Uzbekistan is determined by traditional variables as well as non-biological variables that proxy for environmental quality. Also tested in this study was the hypothesis that regional dummy variables explain variation in mortality not captured by the traditional and non-biological determinants alone. Considering the small sample size, combined with the indirect proxy for environmental quality captured by the non-biological variables used, the results support variation in the probability of infant deaths by oblast due to traditional and non-traditional variables.

The measure of birth rates by age of the mother (BR1) captures factors linked to fertility, education and other available resources. The DRS variable controlled for access to health care services to the extent possible. As shown in Table 6.17, the share of DRS per capita was higher in all years in the Western region than in the other dummy groupings—evidencing the quantity of health care providers cannot fully explain higher rates of mortality in the Western region. It is recognised, however, this variable does not capture access to services or the quality of services. This result supports the importance and challenge at the national level of understanding the impact of spending on health care and the result of improving population welfare (Filmer and Pritchett, 1999). The results agree with the literature that factors influencing health outcomes are not necessarily linked to the availability of health care services and/or practitioners (Makinen et al. 2000). The inclusion of non-biological determinants offers additional support for the argument that environmental determinants in the country are significant in explaining rates of infant mortality—even after controlling for the traditional determinants. The WHO recognised in its 2001 Environmental Health Impact Assessment of Uzbekistan that significant regional differences exist in Uzbekistan with respect to mortality and morbidity, reflecting, in part, "...the concentration of major environmental problems…" (2001). The Western region of Uzbekistan has experienced the most widespread and significant environmental degradation, has the lowest income per capita and continues to suffer from higher rates of infectious diseases, poor access to potable water, reduced access to quality health care services and higher infant mortality (Ataniyazova 2003).

For total infant mortality, the results indicate there is a lower probability of survival in the Western region, than in the other regions, all else being equal. The Western region has the lowest per capita income and, therefore, the results support findings in the literature that poorer populations may also be more susceptible to negative environmental factors which lead to inequality and inequity in health outcomes (Wildman 2001, Goesling and Firebaugh 2004; Kirigia 1997). The results provide empirical support that in the Western region, the region nearest the Aral Sea and where the population is suffering most acutely from the environmental problems associated with the desiccation of the region, the probability of survival is also lower, compared to the East, East-Central and Central regions.

The results support the previously stated difficulty in understanding the cause-effect relationship between socioeconomic, environmental determinants and human health outcomes. For example, the insignificance of the CAC variable in explaining infant mortality (total) does not suggest its irrelevance in impacting on infant mortality in Uzbekistan. As discussed in section 6.3, while the causal link may be clear, detecting the cause and effect is less precise. The findings by Wiggs et al., (2003) support the difficulty in positively identifying the cause-effect of environmental degradation on health in the most environmentally degraded area of Uzbekistan. The difficulty arises due mainly to the many competing factors determining health outcomes, particularly in a study at the oblast level, where omitted variable bias presents problems of confounding and reduces the explanatory power of theoretically important proxy variables of environmental quality and pressures, such as CAC and CAI. The results from IMRT support the hypothesis that where environmental pollution is worse, either from agriculture or industry, residents have a lower probability of survival, especially when combined with reduced socioeconomic conditions.

The analysis supports other findings in the literature that health inequality reflects some notion of absolute deprivation in a population (Pradhan et al. 2002). Although infant mortality may not be a perfect measure of health inequality and/or environmental health, in the analysis it demonstrates variation between populations (urban/rural) as well as location (by region); variation in health outcomes is of significant concern for international measures of well-being and sustainable development. As shown in Table 6.16, total infant mortality is consistently higher in the Western and East region. Both regions have the highest share of the population engaged in agriculture and are the most cotton intensive regions. Throughout Uzbekistan, the share of agricultural workers picking cotton by hand has increased significantly in the post-Soviet period. Quantifying the effects of this change on population health at the ecological level, however, is imprecise. For example, the de-mechanisation of cotton production has been highest in Dzhizak, where infant mortality and mortality from respiratory illnesses is amongst the lowest.

The significance of the regional dummies in IMRT, IMRU and IMRRI indicates that, after controlling for the most widely accepted determinants, regional factors still play a role in variation in infant survival in Uzbekistan, and not only by urban and/or rural location. The role of geographic location within the country and the impacts on survival and overall health outcomes is dependent on numerous factors, including geographical, ethnic and socioeconomic variation that is not fully captured with the available variables used in the study (Buckley 1998; Anderson and Pomfret 2003). In particular, income per capita does not reveal either per capita consumption or the real spending power of the population, particularly in the informal sector. The data also do not reflect the many social and economic problems of widespread, hidden unemployment, as there are serious measurement problems due to reporting biases in the data for Central Asia in general, and Uzbekistan in particular; traditionally accepted measures of socioeconomic progress, including health care professionals and income per capita, do not fully reflect the change in welfare (Pomfret 1999).

When combined with this rising poverty and inequality, the role of environmental degradation on health outcomes cannot be easily differentiated from other determinants of welfare. There is inarguably a gap in well-being between urban and rural areas due to declines in social infrastructure and economic opportunities (Buckley 1998). Socioeconomic and institutional factors influence variation in the probability of survival between urban ad rural populations; widespread migration out of rural areas, for example, particularly of working-aged males is a growing problem with many socioeconomic and health implications for maternal and infant welfare (ICG, 2005).

A unique addition of this study is the specific focus on macro-level environmental factors that may affect variation at the oblast-level. There is an explicit need for the improved understanding of the sources and impacts of environmental degradation on health outcomes throughout Uzbekistan (WHO 2001). The use of oblast data demonstrates a unique perspective of variation in infant mortality in Uzbekistan associated with known environmental threats to health: externalities from irrigation and monoculture cotton production. This study allowed these variables to explain variation in mortality that would not be possible with household level studies due to insufficient data.

The data suggest infant mortality has been decreasing between 1999 and 2003 and can be seen with the inclusion of the time dummies in Table 6.15. The trend of improving rates is not likely when considering declining socioeconomic conditions in the country (Pomfret 1999). Investment in health care is in decline, as are available practitioners per capita. Income inequality has increased significantly since the collapse of the Soviet Union and life expectancy overall is in decline throughout Central Asia. Furthermore, as discussed above, there is evidence of data manipulation at the government level to ensure rates of health and economic development appear to be improving in the country.

The significance of the CAI variable in IMRT (Table 6.14) in (1D) is evidence the variable is capturing a wide range of environmental effects from irrigation in the region, including severe water pollution, salinisation of soils and desertification (Saiko and Zonn 2000). As seen in Table 6.17, irrigated area in the Western and Eastern regions is significantly higher than the other regional groupings for the 5 year period. The significance of CAC in IMRU in Table 6.19 (3G) also supports the widespread and poorly accounted for externalities associated with this sector—including effects which extend far beyond the source of the activity (ICG 2005). The insignificance of CAC in explaining variation in IMRT, IMRR and IMRRI may be due to the underestimation of rates for rural infant mortality, the confounding of total rates due to poor rural reporting, and the relatively small sample captured in the proportionate measure of deaths using IMRRI. Also, unlike CAI, CAC does not show significant variation by regional groupings, thus further evidencing a degree of homogeneity in exposure to cotton production and its effects throughout Uzbekistan (Table 6.17).

The insignificance of the regional dummies in IMRR (Table 6.18) (apart from the Central region in (2B)) can be partially attributed to under reporting of rural deaths in these regions. At the same time, the significance of the CAI variable in (2C) may indicate the externalities associated with rural infant mortality from exposure to irrigation facilities and the negative effects on the water, air and soil on rural inhabitants (Buckley 1998, O'Hara and Hudson 1999, O'Hara et al. 2000). Although the regional dummy variables were insignificant for IMRR, the overall explanatory power of the model supports the need for policy interventions and greater data collection efforts to focus specifically on rural areas, and thereby improving the accuracy in rates and allowing variation to be more thoroughly understood and explained (Buckley 1998).

IMRU is more accurately capturing the magnitude of rates in each oblast as urban reporting is more reliable than in rural areas (Table 6.19) (WHO 1999). The overall explanatory power of this variable (although for a smaller share of the total population) is a better reflection of those factors acting most imminently on reducing the probability of infant survival. Likewise, externalities from cotton and irrigation arguably have a different impact on populations depending on proximity, but the results suggest urban populations are likewise at risk from externalities from this sector (as seen in the significance of both the CAI and CAC variables for IMRU). For example, where direct exposure to agro-chemical applications may impact most directly on rural populations, other externalities associated with environmental quality may influence health in urban areas.

Classifications of urban and rural populations within the CARs may confound information and thus interpretation of indicators of well-being disaggregated by these categories.[38] Many problems are classified as “urban” or “rural” issues and in particular the role of the environment in determining health outcomes for both urban and rural populations is not clear-cut, considering the widespread impact of environmental factors on health throughout the country and the highly rural nature of Uzbekistan. Where indoor air pollutants are a significant concern for a large share of the rural developing world, there is less evidence this is a key cause of respiratory illness in the rural areas of Uzbekistan (Chapter 4). Although its effects are not easily measured, the significance of CAI in explaining both urban and rural

[38] Definitions of rural and urban among the CARs follow standards established under the USSR and they are defined by settlement size where no more than 8,000 in Uzbekistan is classified as rural and the majority must be employed in agriculture (Buckley 1998).

infant mortality (separately) offers a specific point of departure for further analysis and focus of data collection. The variation in determinants of infant mortality between urban and rural populations is supported in the literature (Anderson and Pomfret 2003, Woods 2003) and the fact that SOMSPC and DRS were significant for IMRR and not IMRU reinforces this.

6.9 CONCLUSIONS

The purpose of this study was to explore differentials in infant mortality in Uzbekistan that may be explained by factors which capture environmental characteristics, as well as traditional socioeconomic variables. The motivation for this work is the high reliance on the agricultural sector within Uzbekistan, a sector dominated by monoculture cotton production. Cotton is water and chemical intensive and the widespread irrigation structures facilitating production in this otherwise arid country have brought about severe environmental degradation throughout the country and beyond.

Economic policy in Uzbekistan focuses primarily on short term gains from this cash crop, while discounting the high cost of poor health and widespread morbidity linked to the industry. In light of the severe socioeconomic changes experienced in Uzbekistan in the post-Soviet period and increasing disparities in income and services, understanding and disentangling the impact of known determinants on health outcomes, and specifically on child health, is an inexact process, especially in light of poor, unreliable data. Institutional changes in the country, particularly in the health care sector, have inarguably impacted on well-being in Uzbekistan (Falkingham 1999). Likewise, other changes in the post-Soviet period cannot be fully accounted for with available measures, such as household production in food stuffs and the positive impacts on reducing household poverty (Pomfret 1999).

This study is, nevertheless, a first attempt at quantifying the role of ecological-level environmental factors in explaining the probability of survival as an infant in Uzbekistan. Improving health outcomes and overall welfare and well-being in the country will ultimately be a function of ensuring environmental sustainability, as well as social and economic development. The agricultural sector can ultimately aid in poverty reduction, particularly among the rural poor, if measures at the national level were oriented towards improving market access for farmers, repairing dilapidated and wasteful irrigation structures, and allowing flexibility at the local level with respect to both what to grow and how.

Infant mortality rates are higher in the Western region of Uzbekistan, where the population has also been severely impacted by the negative externalities associated with the agricultural industry. In particular, residents in the West are surrounded by one of the greatest environmental disasters of all time, the desiccation of the Aral Sea. Nonetheless, the public health impact of both living in this region and the wider implications of environmental degradation throughout the country, have yet to be quantified. Therefore, while the causal link between irrigated agriculture, monoculture cotton and agrochemical use on health outcomes is well supported in the literature, quantifying the precise cause and effect between these driving forces and health outcomes is confounded by poor data, measurement difficulties, and the non-linear nature of environmental impacts on health. When compounded with the effects of poor socioeconomic factors and declining access to health care and services, identifying the explanatory power of environmental proxy variables, as was attempted in this study, becomes even more difficult. However, rates of infant mortality across Uzbekistan are high, and cannot be fully explained by the traditionally cited socioeconomic variables. In view of the aforementioned difficulties, the insignificance of the environmental proxy variables in this study does not indicate cotton production is not a key causal factor in determining health outcomes in the country; instead, the results underline the inherent limitations in demonstrating the proposed linkages.

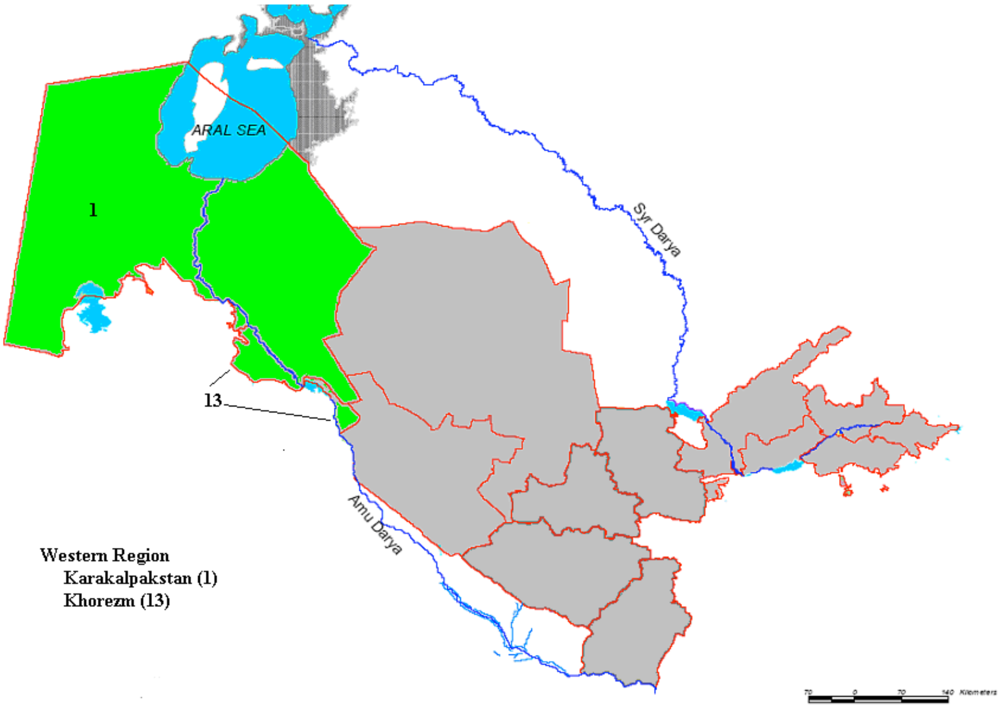
The results support the data in that in the Western region, where environmental degradation is known to be the worst, the probability of survival for infants was found to be lower than in the rest of the country. Furthermore, the regional dummy variables do capture some variation in mortality not explained by the selected independent variables. The importance of the findings within this work, therefore, point to the need for further studies on the role of these macro-level environmental proxy variables and, based on the known impact of environmental degradation on human health, particularly from dust, cotton and agrochemicals, that understanding the role of environmental factors in reducing survival probabilities is an urgent need for future sustainability in the region.

This study also points to a number of areas which urgently require further investigation and attention at the local, national and international level. Environmental externalities in this region are not restricted to Uzbekistan alone and the widespread degradation will have consequences not only beyond Uzbekistan, but beyond the Central Asian Republics. Activities which brought about the loss of the Aral Sea continue today and, even if cotton production is declining in Uzbekistan, the irrigation system is expanding and substitution towards other water intensive crops, such as wheat and rice, does not offer any long term solution to the very activities which brought about current ecological conditions. The country-wide and regional implications of reducing or mitigating the anthropogenic causes of degradation in Uzbekistan, and particularly in the Aral Sea Basin, are not contested.

Nonetheless, the social, economic and environmental benefits of avoiding further degradation in the region continue to be discounted at a much higher rate than the short-term economic earnings from current methods of cotton production and pricing which ultimately contribute to ongoing degradation of the region. Investment from the international community, combined with much needed regional cooperation, is required to improve the efficiency of existing irrigation facilities in the region, and place increased pressure on the government of Uzbekistan to allow greater farmer control, ownership and intervention in production. There also remains an urgent need for alternative markets within the region to allow substitution away from water-intensive crops. There are significant concerns surrounding competing water needs for hydro-electric power among the CARs, combined with agricultural demands and a rapidly growing population. Uzbekistan possesses significant natural resources, including gas and oil, but likewise human capital in the form of a highly literate and educated population. Investment and development of markets for both forms of capital is the only way to ensure long term ecological, social and economic stability in the country.

DATA APPENDIX A

Regional geographic, demographic and economic characteristics of Uzbekistan



A.1. Western Region

The Autonomous Republic of Karakalpakstan (Совет Министров Республики Каракалпакстан)

The Autonomous Republic of Karakalpakstan is located in the heart of the Aral Sea region. The Western region of Uzbekistan is characterised by a higher rate of population growth than the rest of the country (Hanks 2000). Karakalpakstan is the largest region in Uzbekistan stretching over 166,000 km^2 and accounting for 37% of Uzbekistan territory. The region is ethnically divided into 32.8% Uzbeks and 32.1% Karakalpak (2004 state statistics; www.gov.uz). Over 50% of the1.6 million inhabitants (approximately 6% of the Republic's total population) are living in rural areas, with an approximately equal share classified as urban. The population density is low with 9.4 people per km^2, with an equally low share of arable area per capita (rural) with approximately 0.53 ha per person. Of Uzbekistan's 3.5 million ha of cropped area, only 7.6% are in Karakalpakstan. Despite this, 12% of Uzbekistan's total irrigated area lies within the oblast and the dominant crop in the region is cotton, with over 30% of the cropped area sown to cotton in 2003. Nukus is the capital city of Karakalpakstan with approximately 219,000 inhabitants; it is located approximately 250 km south of the Aral Sea. Poor water quality poses a considerable threat to public health in the area where a reported 40,000 (approximately 20% of the population) lack access to piped water (Semenza, et al, 1998)[39] A report assembled by the USAID found that until very recently, over 90% of the population in the Aral Sea region relied on irrigation water for drinking water supply for part of the year—water which is of low quality and often laced with chemical runoff from agro-chemical use (Anderson, 1997; Small, et al., 2001).[40]

Khorezm (Хокимият Хорезмской области)

The Khorezm region is located in the south west of Uzbekistan near the Aral Sea and is semi-aird; it forms part of the Western region of the country. It is 3rd smallest oblast, with a total of 6000 km^2, or approximately 1.4% of the total Uzbek territory. Khorezm borders with Turkmenistan and is home to 1.4 million people, with approximately 150,000 living in the capital city, of Urgench; the historically famous city of Khiva is also located in this oblast. Over 80% of the population lives in remove areas, with 77% classified as rural in 2003 accounting for 6.7% of the Uzbek total rural population and this share of the population continues to grow in Khorezm and throughout Uzbekistan.[41] Population density is amongst the highest in the country with 232 people per km^2 in 2003 (Table 3). Less than 2% of Uzbekistan's total arable/permanent land is in Khorezm, yet approximately 6% of Uzbekistan's total cropped area can be found in the area, with over 232000 ha of cropped area. Of the total land area, 275,000 ha are irrigated, which is approximately 6.5% of total irrigated area in Uzbekistan with 61% efficiency (Uzbek water statistics). They have above the national average of farms sown to cotton, with over 60% and over 50% of total cropped area is sown to cotton, the 4th highest in the country. Cotton ginning, oil extracting and silk spinning factories are a major source of economic activity in the area. There is considerable activity in Khorezm by international organizations and scholars working on water quality and sustainability issues, including UNESCO and ZEF of the University of Bonn. A study by this group noted Khorezm is key in the "water budget" of the Amu Darya (one of the two main feeder rivers to the Aral Sea); they are looking to diversify agricultural lands in the area to move away from cotton production, towards other sustainable methods of agriculture and in the process convert irrigated lands into ecologically sound areas such as orchards and Tugai forests, and preserving economic earnings from the activities that are also sustainable.[42]

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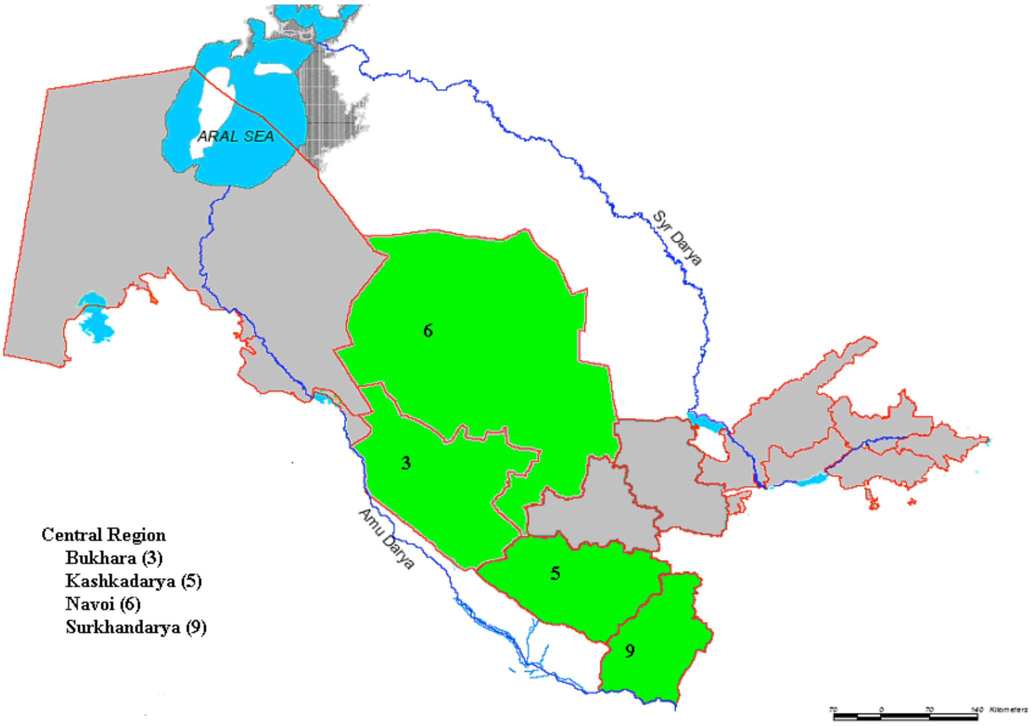
[39] Water distribution system and diarrheal disease transmission (1998)
[40] Environmental policy and technology project: New independent states, issue paper no. 1; January 1997, Robert C. Anderson
[41] Hanks, R., 2000, Central Asian Survey, Uzbekistan and FDI
[42] http://www.zef.de/364.0.html



A.2 Central Region

Bukhara (Бухарской области)

Bukhara is located in the south west of Uzbekistan with the majority of the Kyzylkum desert falling within its territory; the Amudarya forms part of the eastern most border of Bukhara. It's the 3rd largest oblast in the region with 40,300 km^2 or approximately 9% of total Uzbekistan territory. Of the nearly 2.5 million ha of arable and permanent agricultural area in the oblast, over 235,000 ha is cropped, constituting 7.2% of Uzbekistan's total cropped area. There are 1.5 million inhabitants, constituting 5.8% of Uzbekistan's total population, with a total population density of 37.1 per ha and a rural population density of .19. The rural/urban split is 70/30 with 7.3 of Uzbekistan's total rural population residing in Bukhara. Irrigation is the only means by which crops can be cultivated; 274,000 ha are irrigated or 6.4% of Uzbekistan's total irrigated area. Cotton and wheat are the major crops;

Navoi (Навоийской области)

Navoi forms part of the Central Region of Uzbekistan and sits in the middle of the Kyzyl Kum desert, bordering Kazakhstan to the north and Karakalpakstan to the west. It is the second largest oblast, behind Karakalpakstan, with 111000 km^2 total land area, or approximately 25% of total land area in Uzbekistan. On the contrary, it has a very small cropped area, only 3% of Uzbek's total cropped area is found here, or approximately 104,000 ha and 100% of the cropped area is irrigated, although it is the smallest irrigated area in the country. There is a large population in Navoi, with approximately 800,000 people, and 60% are classified as rural (or 3% of Uzbekistan's total rural population). Navoi city is the capital city and approximately 130,000 reside in the capital city. There are large deposits of natural gas and precious metals in Navoi; just over 40% of the cropped area is sown to cotton and they have the highest cotton yields in the country, with very little fluctuation seen between 1999 and 2003 in kg/ha. The area has many open pit mines, gold mines and is home to the largest fertilizer production plant in the country (www.gov.uz). The Asian Development Bank (ADB) is working in Navoi and Kashkadarya on a water and sanitation improvement project to increase access to sanitation and potable water to the region's rural populations—a major problem in the area as throughout the country.[43]

Kashkadarya (Кашкадарьинской области)

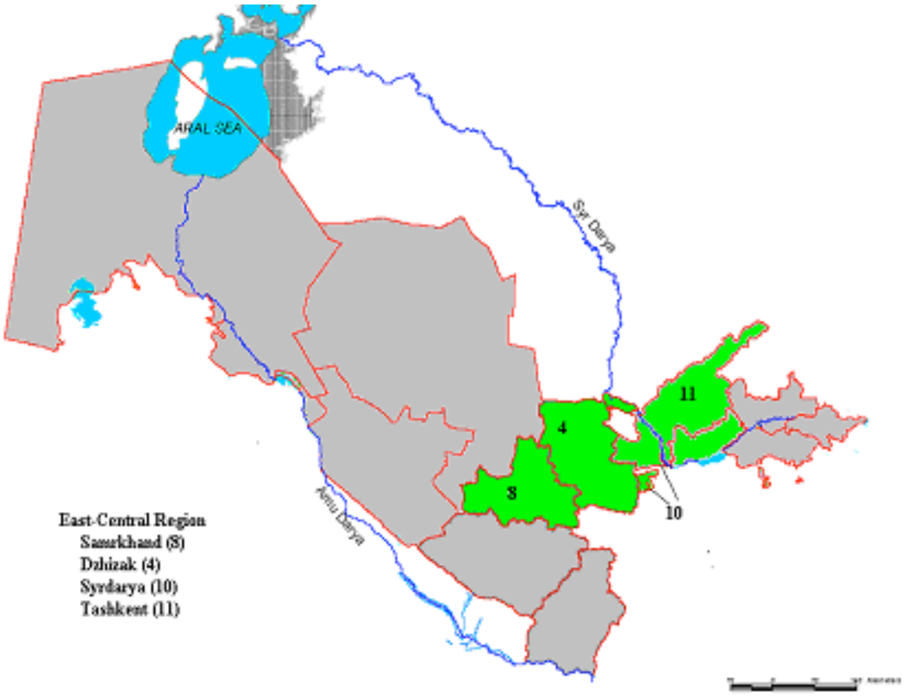
Kashkadarya is located in the Central Region of Uzbekistan and shares a border to the south with Turkmenistan. The region is located in the basin of the Kashkarya River on the western slopes of Pamir-Alay Mountain Massif. The region is endowed with the highest volume of petroleum and natural gas processing. It has the highest share of cropped area out of total cropped area in Uzbekistan and likewise has the highest share of arable area. Approximately 2.3 million people live in the region, accounting for nearly 9% of the total Uzbek population, making it the most densely populated oblast outside the Eastern Region. There is a 70/30 rural/urban population and it has a relatively low population density. Of Uzbekistan's 3.5 million ha of cropped area, nearly 500,000 are in Kashkadarya, making it 2nd in the country of total irrigated area in the oblast, behind Karakalpakstan. The largest share of total cotton harvested in Uzbekistan in 2002 came from Kashkadarya.

Surhandarya (Сурхандарьинской области)

Surhandarya is likewise located in the Central Region of Uzbekistan and is the southern most oblast in the country, bordering with Afghanistan. Located in this oblast is the only international river port in Central Asia located on the Amudarya River. The total area is nearly 21,000 square kilometres and it constitutes approximately 7.5 % of the total cropped area in Uzbekistan and 7% of total arable area. Nearly 230,000 ha are irrigated. Over 1.9 million people live in the region, accounting for 7% of the total Uzbek population. The

[43] http://www.adb.org/Documents/Profiles/PPTA/38074012.ASP

majority of the population lives in rural areas (approximately 77%) and the oblast is divided into 14 administrative districts of which Termez is the capital. There are well-developed deposits of oil and natural gas and oil-extracting and coal industries are currently being developed (www.gov.uz). Cotton is a major crop in the region and it is the largest supplier of fine cotton in the country. The climactic conditions in the region make it possible to also cultivate sugar cane.



A.3. East Central Region

Samarkand (Самаркандской области)

Samarkand is geographically in the centre of Uzbekistan and located at the basin of the Zarafshan River. It has highest population next to Ferghana and population density is approximately 169 people per km^2. The rural population is approximately 74% of the total population. Samarkand city is the administrative centre and there are approximately 16 administrative districts in the region. Samarkand city is the second largest after Tashkent city. The main agricultural products are cotton and wheat and approximately 8% of Uzbekistan's total cotton harvest in 2002 came from Samarkand. It has a high share of irrigated cropland with the 4th largest share of irrigation in the country.

Dzhizak (Джизакской области)

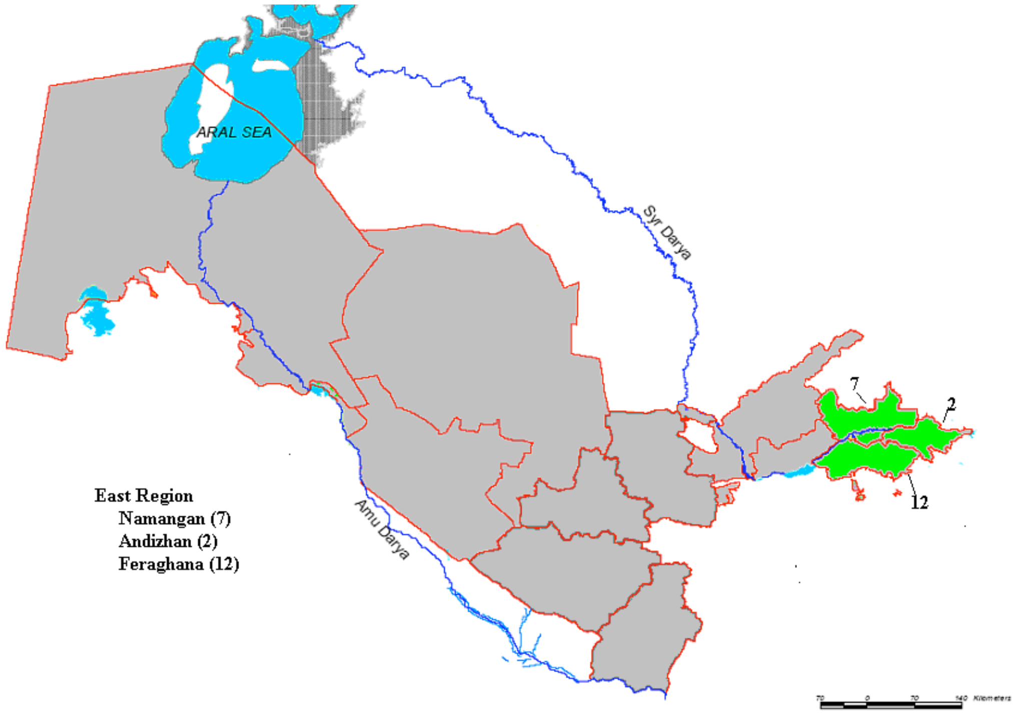
Dzhizak is located in the centre of the country, its northern border with Kazakhstan. The land area is approximately 21200 km^2. The region is divided into 11 administrative areas, with Djizak City the capital. The population is approximately 1 million (4% of Uzbekistan total population) with a population density of approximately 50 per ha; the arable area per rural inhabitant is approximately .67 and the rural/urban split 72/28. The region has over 407,000 ha of cropped area and nearly 300,000 irrigated ha or 7.1 % of Uzbekistan's total irrigated area and 11.8% of Uzbekistan's total arable area. The economy is based primarily on agriculture and it is a main producer of wheat and cotton. Approximately 5% of Uzbekistan's total harvest in 2002 was from Dzhizak.

Syrdarya (Сырдарьинской области)

Syrdarya is located in the centre of Uzbekistan and borders the left bank of the Syrdarya River. It has an area of just over 51,000 km^2 of which nearly 300,000 are irrigated. Syrdarya has the smallest population in Uzbekistan at just around 700,000, but has a relatively high population density of 157 per km^2. The population is 65% rural and 35% urban and the region is divided into 9 administrative districts. The economy in the region is almost entirely based on agriculture, of which cotton and wheat occupy the primary share of production. Approximately 4.5% of Uzbekistan's total cotton harvest in 2002 came from Syrdarya. It has amongst the highest share of highly saline lands in Uzbekistan with 13% of total saline lands in all of Uzbekistan, behind only Karakalpkstan and Bukhara. There remain, nonetheless, thousands of hectares of virgin soil according to the state (www.gov.uz). Improvement in the cotton ginning sector industry is anticipated for the future and it currently has one of the largest hydroelectric power stations in Uzbekistan, profiting from its location in the country directly on the Syrdarya River. Water disputes from upstream users (Kyrgyzstan and Kazakhstan) are a significant issue for the region.

Tashkent (Ташкент области)

Tashkent is located in the northeast part of Uzbekistan in between the Tan Shan Mountain chain and the Syrarya River. The region is divided into 15 administrative areas and Tashkent City is the region and country. More than two million people live in Tashkent City and the region is the most economically developed in Uzbekistan. The population is approximately 60% rural and 40% urban, thus it has the highest share of urban population, next to Navoi. Agriculture is a primary source of revenue for the region and 9% of Uzbekistan's total cropped area is in this country, and it has the 3rd largest irrigated area out of all oblasts. Cotton is the main agricultural product, followed by wheat and fruits.



A.4 Eastern Region

Namangan (Наманганской области)

Namangan is largest of the oblasts located in the Eastern Region and is likewise part of the larger Ferghana Valley and borders the Syrdarya River. The population is around 2 million and it has a 60/40 rural/urban population structure. Population density is relatively high at more than 275 people per km^2. Namangan is divided into 11 administrative districts and Namanagn is the name of the capital city. Approximately 6% of Uzbekistan's total cropped area is in Namangan with roughly the same share of arable area and around 278,000 ha are irrigated. Light industry, including cotton processing and textile factories is a source of income for the region. There is a large factory of dry fruits in the region. The main agricultural products are cotton and silkworm breeding. There are current plans for cotton ginning and other agricultural product processing enterprises in the near future (www.gov.uz).

Andizhan (Андижанской области)

Andizhan is the eastern most oblast in Uzbekistan and forms part of the larger Ferghana Valley region. Andijan borders Kyrgyzstan in the east. It is approximately 4200 km^2 or just under 1% of the total land area in Uzbekistan. Despite this, it has 5% of the country's total arable area in Uzbekistan and over 6% of the country's total cropland and 265,000 ha of irrigated area (6.2% of Uzbekistan total). There irrigation system in the region is extensive and based on a large system of constructed channels. The region has the highest population density in the country with over 550 people per ha (10x the Uzbekistan average) with less than .12 ha of arable land per rural inhabitant. With 9% of Uzbekistan's total population, of the 680,000 inhabitants in the region, 70% are classified as rural, accounting for nearly 10% of Uzbekistan's total rural population. Cotton is a major crop and over 7% of the country's total cropped area sown to cotton is located in Andizhan. Approximately 12% of total cotton harvest in Uzbekistan in 2002 came from Andizhan—the second highest in the country, behind Kashkadarya. Andizhan city is the capital of the oblast with over 300,000 people.

Ferghana (Ферганской области)

Ferghana is located in the Eastern Region and occupies the southern part of the Ferghana Valley in Uzbekistan. It has the largest population in Eastern region and population density is quite high at more than 420 people per $km^{2.}$ Second only to Samarkand, it has the largest share of the Uzbekistan population out of all other oblasts (approximately 11%). The region is divided into 15 administrative districts of which Fergana City is the capital. The population is approximately 70% rural and 30% urban. Over 290,000 ha are cropped, accounting for 7.7% of the Uzbekistan total; it has one of the largest shares of irrigated area in Uzbekistan with over 356,000 ha irrigated. Energy in the region is supplied by thermal power. Cotton production, silkworm-breeding and wine production are the main agricultural activities. Approximately 9.7% of total cotton harvest in 2002 came from Ferghana.

DATA APPENDIX B

B.1 Descriptive Statistics of all variables explored in the analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
ARABPC	65	29.66	17.75	12.10	69.59
BEDS1	65	51.29	7.58	35.30	64.40
BEDS2	65	53.76	6.70	42.90	66.30
BR1	65	18.08	7.24	1.98	43.83
BR2	65	200.59	23.75	146.23	251.78
BR3	65	169.64	27.38	137.20	245.12
BR4	65	94.01	20.79	64.61	132.35
BR5	65	33.72	11.44	18.64	55.06
CTTNPC	65	0.11	0.06	0.05	0.33
CTTNSH	65	81.87	30.03	3.30	160.20
CTTNSHR	65	7.69	2.00	2.83	12.73
DAY	65	231.08	70.81	99.00	356.00
DAY2	65	50.83	24.44	3.00	94.00
DRS	65	25.34	3.60	19.30	35.50
EDU	65	4917.22	7824.65	387.54	36258.30
EXPPC	65	124.90	84.39	16.90	318.10
HOMPAT	65	70.73	57.40	15.70	232.80
IMR	65	18.01	2.63	13.60	24.60
IMRPERI	65	56.94	16.49	36.20	93.90
IMRR	65	16.56	2.67	11.70	21.70
IMRRI	65	84.43	27.45	28.30	142.00
IMRU	65	21.84	5.65	14.60	46.00
IRRIG	65	0.34	0.17	0.17	0.81
MATCENT	65	154.14	73.17	32.00	346.00
OUT	65	283.32	91.20	135.00	471.00
PAT	65	92.16	36.50	25.90	152.40
POLY	65	180.80	65.97	72.00	341.00
SOMSPC	65	142.26	96.70	23.20	450.70
TFR	65	2.62	0.36	2.13	3.53
TFRR	65	2.84	0.45	2.23	3.88
TFRU	65	2.16	0.25	1.79	2.76

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B.2. Simple correlations-all variables explored in the analysis

	somspc	exppc	imrr	imru	imr	imrperi	imrri	edu	br1	br2	br3	br4	br5	tfr	tfrr	tfru	matcent	beds1	beds2	drs	day	day2	out	poly	pat	hompat	cttnshr	arabpc	cttnsh	irrig	cttnpc
somspc	1.00																														
exppc	0.97	1.00																													
imrr	-0.57	-0.57	1.00																												
imru	-0.35	-0.35	0.29	1.00																											
imr	-0.61	-0.61	0.86	0.69	1.00																										
imrperi	-0.06	-0.01	0.38	0.09	0.28	1.00																									
imrri	-0.54	-0.54	0.37	0.50	0.56	-0.44	1.00																								
edu	0.46	0.54	-0.35	-0.20	-0.37	0.05	-0.31	1.00																							
br1	-0.61	-0.61	0.52	0.74	0.74	0.04	0.60	-0.38	1.00																						
br2	-0.55	-0.53	0.28	0.23	0.24	-0.17	0.44	-0.36	0.52	1.00																					
br3	-0.27	-0.31	0.17	-0.30	-0.07	-0.19	0.29	-0.16	-0.12	0.38	1.00																				
br4	-0.29	-0.36	0.21	-0.14	0.08	-0.23	0.45	-0.18	-0.04	0.28	0.81	1.00																			
br5	-0.24	-0.30	0.25	-0.15	0.10	-0.23	0.44	-0.10	-0.06	0.12	0.79	0.91	1.00																		
tfr	-0.47	-0.52	0.32	-0.04	0.16	-0.24	0.53	-0.30	0.20	0.63	0.90	0.87	0.82	1.00																	
tfrr	-0.43	-0.49	0.31	-0.10	0.12	-0.27	0.45	-0.25	0.09	0.55	0.90	0.88	0.85	0.97	1.00																
tfru	-0.45	-0.48	0.27	0.16	0.35	-0.06	0.61	-0.37	0.40	0.30	0.38	0.48	0.36	0.49	0.33	1.00															
matcent	0.22	0.31	-0.16	-0.33	-0.30	-0.11	-0.21	0.34	-0.22	-0.04	-0.11	-0.26	-0.13	-0.17	-0.10	-0.49	1.00														
beds1	-0.07	0.01	0.01	-0.10	-0.02	0.31	0.04	0.08	-0.08	-0.01	0.02	-0.13	-0.16	-0.08	-0.21	0.39	-0.06	1.00													
beds2	0.00	0.02	-0.03	-0.06	0.02	0.16	0.09	-0.07	-0.02	-0.11	-0.10	-0.15	-0.19	-0.17	-0.30	0.48	-0.25	0.84	1.00												
drs	0.23	0.23	-0.33	0.15	-0.20	0.12	-0.23	0.18	-0.03	-0.07	-0.24	-0.35	-0.31	-0.28	-0.29	-0.24	0.28	0.10	0.05	1.00											
day	0.11	0.19	-0.14	-0.30	-0.26	-0.09	-0.11	0.17	-0.18	0.12	0.06	-0.09	-0.01	0.03	0.06	-0.32	0.79	0.02	-0.15	0.32	1.00										
day2	-0.34	-0.32	0.26	-0.08	0.24	-0.42	0.56	-0.21	0.14	0.27	0.24	0.29	0.32	0.34	0.32	0.37	0.20	0.13	0.14	-0.20	0.39	1.00									
out	0.15	0.26	-0.16	-0.31	-0.30	-0.04	-0.20	0.34	-0.22	0.17	0.01	-0.21	-0.16	-0.05	-0.02	-0.41	0.88	0.12	-0.12	0.37	0.91	0.26	1.00								
poly	0.25	0.34	-0.27	-0.29	-0.38	0.05	-0.33	0.26	-0.25	0.02	-0.03	-0.21	-0.13	-0.11	-0.06	-0.49	0.78	-0.02	-0.21	0.43	0.94	0.04	0.89	1.00							
pat	-0.02	0.08	-0.06	-0.10	-0.03	-0.26	0.24	0.03	0.06	0.11	-0.17	-0.26	-0.21	-0.14	-0.19	0.07	0.60	0.28	0.25	0.11	0.65	0.66	0.64	0.46	1.00						
hompat	0.03	0.11	0.11	-0.03	0.12	-0.05	0.03	0.12	0.00	0.11	-0.36	-0.44	-0.47	-0.33	-0.36	-0.08	0.37	0.37	0.28	-0.04	0.29	0.45	0.45	0.14	0.63	1.00					
cttnshr	-0.03	-0.05	0.19	0.04	0.14	-0.03	0.09	0.01	0.03	0.00	0.13	0.15	0.12	0.11	0.12	0.06	-0.06	-0.02	-0.01	0.06	0.01	0.15	-0.03	-0.04	0.00	-0.07	1.00				
arabpc	-0.20	-0.27	0.26	-0.22	0.10	0.13	0.08	-0.15	-0.17	-0.09	0.54	0.66	0.63	0.48	0.53	0.41	-0.52	0.01	0.03	-0.38	-0.41	-0.03	-0.49	-0.43	-0.50	-0.44	0.11	1.00			
cttnsh	-0.35	-0.26	0.41	0.18	0.37	0.18	0.33	-0.17	0.45	0.33	0.07	-0.06	0.01	0.17	0.10	0.19	0.45	0.16	0.01	0.17	0.48	0.27	0.48	0.42	0.53	0.19	0.10	-0.29	1.00		
irrig	-0.30	-0.36	0.45	-0.03	0.37	0.36	0.10	-0.18	0.01	-0.26	0.29	0.47	0.49	0.26	0.27	0.45	-0.53	0.13	0.18	-0.20	-0.47	-0.04	-0.56	-0.49	-0.47	-0.40	0.15	0.84	-0.12	1.00	
cttnpc	-0.19	-0.24	0.37	-0.08	0.22	0.56	-0.12	-0.22	0.01	-0.14	0.27	0.32	0.26	0.20	0.17	0.40	-0.61	0.22	0.25	-0.17	-0.51	-0.34	-0.57	-0.42	-0.61	-0.48	0.09	0.72	-0.11	0.84	1.00

B.3 Description of available and relevlant oblast-level data

Variable	Symbol	Years Available	Definition
Mortality			
Infant mortality rate	IMR	1996-2003	Deaths between 0-1 per 1000 Total
Infant mortality rate Rural	IMRR	1996-2003	Deaths between 0-1 per 1000 Rural births
Infant mortality rate Urban	IMRU	1996-2003	Deaths between 0-1 per 1000 Urban births
Perinatal mortality	IMRPERI	1997-2001	Deaths per 1000 live births due to illnesses originating between 0-7 days
Maternal mortality	MMR	1994-2003	Deaths per 100,000 live births
Rate of Complexities in Labour	COM	1997-2003	Complexities in labour and postnatal per 100,000 women
Education			
Graduates of higher education	EDU	1999-2003	Graduates secondary education per capita secondary school age
Demographics			
Population share (Total)	POPA	1991-2005	Share of total population in each oblast (%)
Population share (Male)	POPM	1991-2005	Share of male population in each oblast (%)
Population share (Female)	POPF	1991-2005	Share of female population in each oblast (%)
Population share Urban	POPU	1991-2005	Share of urban population (%)
Population share Urban Male	POPUM	1991-2005	Share of urban male population (%)
Population share Urban Female	POPUF	1991-2005	Share of urban female population (%)
Population share Rural	POPR	1991-2005	Share of rural population (%)
Population share Rural Male	POPRM	1991-2005	Share of rural male population (%)
Population share Rural Female	POPRF	1991-2005	Share of rural female population (%)
Tuberculosis	TB	1995-2003	Incidence rate of TB per 100,000 of total population
Dysentery	DYS	1995-2003	Incidence rate of Dysentery per 100,000
Mental disorders	MEN	1995-2003	Incidence rate of Mental Disorders per 100,000
Infant mortality by cause			
Infectious/parasitic	IMRIP	1996-2003	Cause of infant deaths per 10,000 births
Respiratory	IMRRI	1996-2003	Cause of infant deaths per 10,000 births
Birth defects	IMRBD	1996-2003	Cause of infant deaths per 10,000 births
Perinatal illnesses	IMRPERI	1996-2003	Cause of infant deaths per 10,000 births
poisonings/injuries	IMRPI	1996-2003	Cause of infant deaths per 10,000 births

Variable	Symbol	Years Available	Definition
Fertility/age specific birth rates			
Total fertility (All Ages)	TFR	1997-2003	Total fertility rate--children per 1000 woman of child bearing age
Total fertility (All Ages Urban)	TFRU	1997-2003	Total fertility rate--children per 1000 urban woman of child bearing age
Total fertility (All Ages Rural)	TFRR	1997-2003	Total fertility rate--children per 1000 rural woman of child bearing age
Birth rates Age 15-19	BR1	1997-2003	Total births rate per 1000 women aged 15-19--children per woman
Birth rates Age 20-24	BR2	1997-2003	Total fertility rate per 1000 women aged 20-24--children per woman
Birth rates age 25-29	BR3	1997-2003	Total fertility rate per 1000 women aged 25-29--children per woman
Birth rates age 30-34	BR4	1997-2003	Total fertility rate per 1000 women aged 30-34--children per woman
Birth rates age 35-39	BR5	1997-2003	Total fertility rate per 1000 women aged 35-39--children per woman
Birth Rates			
Crude birth/death/natural increase	CBR	1997-2003	Crude births per 1000 of the total pop (All Ages)
total births both	TBR	1999-2003	Total births by rural/urban/total
total births urban	TBRU	1999-2003	Total births by rural/urban/total
total births rural	TBRR	1999-2003	Total births by rural/urban/total
Personal Illness			
Doctors per 10,000	DRS	2000-2004	General practitioners per 10,000 of total population
Private Hospitals	HOSP	2000-2003	Total private hospitals in region
Hospital beds	BEDS1	1997-2003	Total hospital Beds per 10,000 of total population (various sources)
Hospital Beds	BEDS	2000-2004	Total Hospital Beds per 10,000 of total population
Hospital Beds Public	BEDS2	2000-2004	Total Beds ('000) per oblast
Outpatient clinics	OUT	1996-2003	Total outpatient clinics in region
Outpatient polyclinics	POLY	1997-2001	Outpatient polyclinics total
Day clinics and hospital	DAY	1997-2001	Day clinics total in Uzbekistan
Day, poly, hospitals	DAY2	1997-2001	All day clinics, polyclinics and hospitals Total
Patients treated	PAT	1997-2001	Patients treated ('000) in day clinics, hospitals and polyclinics
Patients treated in the home	HOMPAT	1997-2001	Patients treated ('000) in at home
Gynaecological beds	GBEDS	1997-2001	Gynaecological beds per 10,000 of population
maternal health centres	MHC	1997-2003	total by regions

Variable	Symbol	Years Available	Definition
Socioeconomic			
Soms per capita ('000)	SOMSPC	2000-2004	Soms per capita ('000)
Annual earnings	ERN	1998-2004	Million Soms
Annual expenditures/savings	EXPS	1998-2004	Million Soms
Earnings per capita	ERNPC	1998-2004	Earnings '000 Soms/per capita
Expenditures/savings pc	EXPPC	1998-2004	Expenditures '000 Soms/per capita
Goods and services	GOODPC	2003-2004	Annual expenditure on goods and services per capita ('000) soms
Agro production output	AGR	1999-2004	Actual prices ('millions of soms)
Agro production from plant products	AGRP	1999-2004	Actual prices ('millions of soms)
Agro production from livestock	AGRL	1999-2004	Actual prices ('millions of Soms)
Agro employment	EMPA	95,99,03,04	Share of population employed in agriculture
Land use			
Agro area that is permanent and arable	PERM	2000-2005	Permanent and arable area of total agricultural area ('000 ha)
Agro area that is arable	ARAB	2000-2005	Share of agricultural area that is arable ('000) ha
Total cropped area	CROP	1999-2004	Agricultural area that is cropped (total cropped area) '000 ha
Shirkat farms	SHIRK	1999-2004	Share that are shirkat out of total cropped area ('000) ha
Dhekan farms	DEKH	1999-2004	Share of total cropped area ('000) ha that is dhekan classified
Farmers' enterprises	FARM	1999-2004	Share of total cropped area ('000) ha classified as farmers' farm
Area under grains	GRNA	1999-2004	Share of total cropped area under grains
Shirkat farms sown to grain	GRNSH	1999-2004	Share shirkat farms sown to grain '000 ha
Dhekan farms sown to grain	GRNDEK	1999-2004	Share of dhekan farms sown to grain '000 ha
Farmers' enterprises sown to grain	GRNFRM	1999-2004	Share of Farmers' enterprises sown to grain '000 ha
Area under cotton	CTTN	1999-2004	Share of total cropped area under cotton '000 ha
Shirkat farms sown to cotton	CTTNSH	1999-2004	Share of Shirkat farms sown to cotton '000 ha
Dhekan sown to cotton	CTTNdek	1999-2004	Share of farmers' enterprises sown to cotton '000 ha
Grain harvest all farms	HRVG	1999-2004	Total grain harvest on all land '000 tonnes
Grain harvest on Shirkat	HRVGSH	1999-2004	Total grain harvest on Shirkat farms '000 tonnes
Grain harvest on dhekan	HRVGDEK	1999-2004	Total grain harvest on farmers' enterprises '000 tonnes
Wheat harvest all farms	HRVW	1999-2004	Total wheat harvest on all land '000 tonnes
Wheat harvest on Shirkat	HRVWSH	1999-2004	Total wheat harvest on Shirkat farms '000 tonnes
Wheat harvest on dhekan	HARVWDEK	1999-2004	Total wheat harvest on farmers' enterprises '000 tonnes

Variable	Symbol	Years Available	Definition
Land use			
Cotton harvest all farms	HRVC	1999-2002	Total cotton harvest on all land '000 tonnes
Cotton harvest shirkat	HRVCSH	1999-2002	Total cotton harvest on Shirkat '000 tonnes
Cotton harvest dhekan	HRVCDEK	1999-2002	Total cotton harvest on farmers' enterprises '000 tonnes
Share of grain from total output	GRNshr	1999,02,04	Share of grain from total agricultural output (%)
Share of cotton from total output	CTTNshr	1999,02,04	Share of cotton from total agro output (%)
Cotton output	CTTNOut	1999-2004	change in output (%) from previous year
Total grain yields	YLDG	1999-2004	100 kg/ha grain yields from total area sown to grain
Grain yields on Shirkat	YLDGSH	1999-2004	100kg/ha grain yields from area sown to grain on Shirkat
Grain yield dhekan	YLDGDEK	1999-2004	100kg/ha grain yields from area sown to grain farmers' enterprises
Total wheat yeilds	YLDW	1999-2004	100 kg/ha wheat yields from total area sown to wheat
Wheat yields shirkat	YLDWSH	1999-2004	100kg/ha wheat yields from area sown to wheat on Shirkat
Wheat yields dhekan	YLDWDEK	1999-2004	100kg/ha wheat yields from area sown to wheat on farmers' enterprises
Total cotton yields	YLDC	1999-2002	100 kg/ha cotton yields from total area sown to cotton
Total cotton yields shirkat	YLDCSH	1999-2002	100 kg/ha cotton yields from Shirkat area sown to cotton
Total cotton yields dhekan	YLDCFRM	1999-2002	100 kg/ha cotton yields from farmers' enterprise area sown to cotton
Total land area	LAND	96,00,05	Total land area '000 km^2
Total irrigated area	IRRG	91,95,00	total irrigated area '000 ha
Irrigated area as % of total	IRRGSHR	91,95,00	% irrigated area as share of Uzbekistan total
Irrigated area low salinity	SALLOW	91,95,00	000 ha classified as Low salinity
Irrigated area medium salinity	SALMED	91,95,00	000 ha classified as Medium salinity
Irrigated area high salinity	SALHIGH	91,95,00	000 ha classified as High salinity
Share irrigated area low salinity	SALLOW	91,95,00	Share of irrigated area classified as low salinity %
Share irrigated area medium salinity	SALMED	91,95,00	Share of irrigated area classified as medium salinity %
Share irrigated area high salinity	SALHIGH	91,95,00	Share of irrigated area classified as high salinity %
Water use for cotton per ha	WATCTTN	2000	Water used for cotton M^3/ha
Total water use for cotton	WATCTTNT	2000	Water used in total for cotton MLN M^3
Efficiency of irrigation system	IRRGEFF	2000	Share of irrigation system that is efficient (%)
Total water use/including loss	WATUSE	2000	Million M^3 total water use for all crops/including losses
Arable area per capita rural population	ARABPC	2000-2005	Arable area (ha) per rural inhabitant
Irrigated area per capita rural pop	IRRIG	1991,1995,00	Irrigated area (ha) per rural inhabitant
Area under cotton (ha) per capita rural inhabitant	CTTNPC	1999-2003	Area sown to cotton (ha) per rural inhabitant

Variable	Symbol	Years Available	Definition
Mortality			
Infant mortality rate	IMR	1996-2003	Deaths between 0-1 per 1000 Total
Infant mortality rate Rural	IMRR	1996-2003	Deaths between 0-1 per 1000 Rural births
Infant mortality rate Urban	IMRU	1996-2003	Deaths between 0-1 per 1000 Urban births
Perinatal mortality	IMRPERI	1997-2001	Deaths per 1000 live births due to illnesses originating between 0-7 days
Maternal mortality	MMR	1994-2003	Deaths per 100,000 live births
Education			
Graduates of higher education 1999-2003	EDU	1999-2003	Graduates secondary education per capita secondary school age
Demographics			
Population share (Total)	POPA	1991-2005	Share of total population in each oblast (%)
Population share (Male)	POPM	1991-2005	Share of male population in each oblast (%)
Population share (Female)	POPF	1991-2005	Share of female population in each oblast (%)
Population share Urban	POPU	1991-2005	Share of urban population (%)
Population share Urban Male	POPUM	1991-2005	Share of urban male population (%)
Population share Urban Female	POPUF	1991-2005	Share of urban female population (%)
Population share Rural	POPR	1991-2005	Share of rural population (%)
Population share Rural Male	POPRM	1991-2005	Share of rural male population (%)
Population share Rural Female	POPRF	1991-2005	Share of rural female population (%)
Tuberculosis	TB	1995-2003	Incidence rate of TB per 100,000 of total population
Dysentery	DYS	1995-2003	Incidence rate of Dysentery per 100,000
Mental disorders	MEN	1995-2003	Incidence rate of Mental Disorders per 100,000

DATA APPENDIX C

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7 CONCLUSIONS

7.1 SUMMARY

This purpose of this research was to advance the overall understanding of the relationship between economic activity linked to the agricultural sector in the CARs and the impact on human health outcomes in the form of high child mortality. The work is a first step in trying to identify externalities associated with economic activities that fundamentally compromise ecological quality and, in turn, reduce human health in the CARs. Health has many dimensions and can be measured in numerous ways. The selection of child mortality as a key indicator of social, economic and ecological health makes it an effective and easily comparable indicator across countries and levels of economic development. Although this measure does not inherently capture ecological quality and/or social capital within a society, the determinants of infant and under-5 survival clearly indicate that the chance of survival past age five depends on a complex set of economic, ecological and social factors. Child mortality is therefore a comprehensive environmental health indicator as well as a measure of health inequality within and between countries.

This research pulls together contributions from a wide range of disciplines in order to investigate the social, ecological and economic problems unique to the CARs. The work establishes a point of reference for future research on these issues and points to the need to incorporate the tools and methods of a variety of disciplines to address the challenges between economic growth and development, when considering social and ecological needs. Only by incorporating a wide range of techniques can sustainable development in the face of global climate change, rapid population growth and increasing globalisation be comprehensively addressed.

Chapter 4 provides evidence that traditional arguments of social and economic disparity in explaining high child mortality in the fSU and specifically within the CARs may not capture the root cause of endemically high rates in the region. The link between long term environmental degradation and its ultimate impact on social well-being has been poorly investigated in the literature due primarily to measurement issues and the political context in which the environmental degradation has occurred. The empirical evidence put forth in Chapters 5 and 6 lends weight to the hypotheses that factors other than economic and social have resulted in low levels of health in the region. Although empirical exercises are always imperfect in light of missing information, trends in the data provide evidence there is a unique threat to health in the CARs that cannot be explained by traditional determinants alone. The uncertainty posed by measurement error and omitted variable bias does not preclude the need for urgent analysis and extended cooperation in understanding the linkages.

The implications of these findings extend beyond the Central Asian region, as the very activities which have brought about the current social, ecological and economic situation in the CARs are compromising sustainability around the world. The work, therefore, points to a widespread need of researchers to combine expertise and focus on the interaction of economic, ecologic and social systems in framing sustainable policies.

7.2 FUTURE RESEARCH

Placing a monetary value on excess child mortality attributable to ecological factors within the CARs is an important next step in this work. The quantification of excess mortality attributable to living in the CARs (Chapter 5) and in various regions in Uzbekistan (Chapter 6) provides a genuine starting point from which to attempt to monetise lost future productivity and other costs associated with high child mortality. In addition, the framework and methodology used in linking socioeconomic and environmental factors to human health outcomes will be expanded to explore variation in adult morbidity and mortality at the oblast level in the CARs (at the national level) and in Uzbekistan (at the regional level). There is arguably greater scope for linking proportionate mortality among adults by cause of death to geographic, socioeconomic and environmental factors do to a larger number of observations, broader set of explanatory variables and more reliable reporting in the data.

Future work will focus on the valuation of different environmental and social externalities associated with the agricultural industry. In particular, in looking at adult morbidity and mortality resulting from this sector, we will be looking to measure foregone earnings as well as lost productivity in the form of falling cotton and grain yields. Ultimately the productivity of the economy depends on the quantity and quality of natural and social capital. Identifying the high costs associated with low human and natural capital resulting from unsustainable uses of resources will provide improved evidence for the need to re-frame institutional reliance on the cotton industry. A cost of illness approach in valuing morbidity and mortality on the economy is also of interest based on available adult mortality data. A general estimate in gross terms under a cost-benefit analysis framework could provide measures of potential benefits in expenditures towards disease prevention linked to ecological factors. The unique political and economic characteristics in the CARs prevent many direct and indirect valuation techniques common to environmental cost-benefit analysis. Valuing social and ecological losses is likewise burdened by imperfect and limited information with respect to inputs and poor data availability. However, any attempt at valuing the ecological losses and social costs associated with ongoing cotton monoculture in the region advances support for a change in institutional reliance on this sector.

Finally, based on the findings in Chapter 6, in particular, future work on the source of morbidity and mortality across age groups at the oblast level in Uzbekistan is warranted. A very rich dataset has been acquired with a large number of variables that would help to explain oblast-level variation in adult mortality by cause of death, male, female and urban/rural. Important data on migration and employment is available for the entire population, allowing us to look at trends in illnesses and thus improving the explanatory power of variables linked to long term environmental, social and economic factors. Adult mortality was not included in this work as there is a large and separate literature on the determinants of adult mortality and it was ultimately outside the scope of this work.

The findings within this thesis point to the direction of much needed research identifying the interactions between economic activities, the environment and the ultimate impact on human welfare. These three pillars of sustainable development do not operate in isolation and any hope at an equitable and secure future requires a holistic approach to all three components. Specific political conditions in the CARs render these three areas uniquely difficult to address and certainly in any comprehensive way. The cooperation of the international community is essential to put pressure on the Central Asian governments to ensure protection of human rights in the region, but likewise protection and improvement of the local environment and the externalities associated with the loss of the Aral Sea and the ongoing activities which ultimately brought about this extreme environmental disaster. The desiccation of the region from irrigated agriculture is evidence that environmental issues do not operate in isolation and the impacts of advancing desertification in the region is already spreading far beyond the CARs. Likewise, as population growth continues, desertification worsens and agricultural yields decline as temperatures rise and lands continue to degrade. Only through international and intra-regional cooperation to these issues can future progress can be made.

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