Health and Wellbeing in the Changing Urban Environment: a Systems Analysis Approach

An Interdisciplinary Science Plan

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International Council for Science

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Report of an ICSU Planning Group

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Preface

Human health is identified in the ICSU Strategic Plan 2006-2011 as a new research priority, with the stated goal "to ensure that health considerations are duly taken into account in the planning and execution of future activities by building on the relevant strengths of Scientific Unions and Interdisciplinary Bodies."

To more clearly define how ICSU might contribute to science for human health, a Scoping Group was established in 2006. The Scoping Group's role was to consider the health initiatives already being developed within the ICSU community and identify additional areas or approaches where ICSU might add value to these initiatives. A number of ICSU's Scientific Unions and Interdisciplinary Bodies began developing an initiative on Science for Health and Wellbeing from as early as 2002. In 2007, the Earth Systems Science Partnership, which brings together ICSU's global environmental change programmes, published a science plan for global environmental change and human health. More recently, the ICSU Regional Office for Africa has carried out an analysis of health research needs for the continent.

The Scoping Group identified a number of broad criteria and concluded that any further ICSU initiative on health should:

- be international (relevant to more than one region) and interdisciplinary;
- build on the synergies between existing activities and interests of the ICSU membership;
- add value to other ongoing or planned activities;
- fill a unique niche that other international initiatives do not address;
- incorporate links with pertinent international bodies and/or networks outside the ICSU family, as necessary;
- generate new scientific insights of significant relevance to health (and other) policies;
- clearly define policy audience(s) at the outset;
- focus primarily on preventing disease and promoting health and wellbeing rather than treatment and therapies;
- fit within the context of the Millennium Development Goals and the broader agenda of science for sustainable development.

Using these criteria, the topic identified for further development was "a systems analysis approach to health and wellbeing in the changing urban environment." This decision also recognized the increasing awareness and interest, in both the policy and research realms, of links between modern urban human ecology and the risks of a range of adverse health outcomes.

Accordingly, the Scoping Group's report laid out a preliminary conceptual framework for organizing and understanding the complex matrix of factors that influence urban health and wellbeing (ICSU, 2007).

After consultation with the ICSU scientific community, a new Planning Group was established in 2008 to carry forward the ideas from the scoping exercise in developing the present science plan. The terms of reference and membership of this Planning Group are in Annex 1. Since a systems analysis approach was one of the unique features of the proposed initiative, it was decided to develop the science plan in partnership with the International Institute of Applied Systems Analysis (IIASA). A scientific workshop was held at IIASA in January 2008 to bring together scientists from the ICSU community and launch discussions on the design of the research programme. The Planning Group met on six occasions during 2008-2010 to carry out its task; Annex 1 also briefly summarizes Planning Group meetings, including discussions with urban policy and decision makers and urban researchers in France and China.

The science plan that follows is the product of an interdisciplinary and international planning exercise, which it has been ICSU's role to broker and manage. The implementation of this plan now depends on the support and commitment it can attract from its target audiences – the scientific community and multiple urban stakeholders, including those decision-makers whose actions help to determine the context for urban health.

Deliang Chen
Executive Director

Executive Summary

Over half of the world's population lives in urban areas and the urban population is increasing by about 2% annually. More than two billion people are expected to be added to urban populations over the next three decades and a significant proportion of these will be living in informal or slum settlements. Urbanization presents opportunities and risks, as well as enormous challenges for maintaining and improving human health and wellbeing. Systems analysis, which is explicitly designed to deal with complexity, and which draws on insights and inputs from diverse scientific disciplines, is an approach which has unique potential to address these issues.

Urban areas are extremely complex environments in which a large number of environmental, social, cultural and economic factors have an impact on individual and population health and wellbeing. Urban governance and decision-making structures associated with managing these various factors are usually comprised of variable elements in different regional and local contexts; they reflect different degrees of coordination and coherence. Better use of existing and yet-to-be-developed scientific knowledge can surely have a positive impact on urban health and wellbeing. The challenge for the scientific community is to generate and communicate this knowledge in a way that can usefully inform policy choices based on the realities of the urban environment.

This science plan proposes a new conceptual framework for considering the multi-factorial nature of both the determinants and the manifestations of health and wellbeing in urban populations. General criteria are presented for the development of research projects within this framework and illustrative examples of potential projects described. Projects envisaged for this science plan should be multi-disciplinary and collaborative, utilize systems analysis modelling methodology using feasibly-obtainable data, simultaneously address multiple aspects of urban health, and be designed to generate understanding and products useful to policy-makers.

In addition to stimulating specific research projects, a new science programme for urban health and wellbeing should also focus on: developing new methodologies and identifying data needs and knowledge gaps; building and strengthening scientific capacity; and facilitating communication and outreach.

In line with the 'standard' ICSU model for programme implementation these activities should be overseen and guided by a dedicated international, interdisciplinary scientific committee and an International Programme Office should be established to ensure effective implementation. This is envisaged as a 10-year initiative, to allow sufficient time for the research and policy communities that are concerned with urban health and wellbeing to adopt systems analysis approaches.

This science plan is ambitious and requires a paradigm shift in the conceptualization and implementation of urban health research. Its realization depends on the engagement of multiple stakeholders: scientists, policy-makers, representatives of civil society and funders. Some of the potential key partners are identified in this report. It is proposed that the International Institute of Applied Systems Analysis (IIASA) be formally involved as a co-sponsor of the programme. The ICSU Unions and several existing Interdisciplinary Bodies would also play key roles.

The urban health and wellbeing programme would not be starting from scratch; a relatively small but active international research community is already working in this area. Research funding bodies are already showing an interest in this area, for example the Office of Behavioral and Social Sciences Research at the US National Institutes of Health has identified systems approaches to public health as a priority area in its strategic prospectus (Mabry *et al.* 2008). During the development of the science plan, discussions with local urban decision-and policy-makers in both France and China indicated a strong level of support and interest.

A number of recent policy documents from UN HABITAT, the World Health Organization and other bodies suggest that it is time for new approaches to managing cities, enhancing healthy urbanization, and addressing major health challenges, focusing more on understanding causes and prevention than on medical intervention and treatment. Social determinants of health and health differentials have recently risen in the political agenda. The traditional discourse on extending the average length of life is being supplemented by an increasing focus on improving the quality of life and reducing preventable health inequities. The time is right to launch a new interdisciplinary and international programme taking on board all of these considerations, focusing on the urban environment, where major health and wellbeing challenges in the 21st century will be increasingly manifest.

1. Introduction

In the context of global environmental, economic and social change, perhaps no phenomenon is more striking than urbanization. Already, more than half of the world's population lives in urban places (Amhad, 2007). Urban lifestyles and the increasing diversity of urban conditions have not only created new social hierarchies and cultural rules, but also a new set of roles for health care systems and changing patterns of access to and demand for health and other resources within and between cities. Urbanization represents both opportunity and risk, and a fresh set of challenges for those concerned with protecting and promoting human health and wellbeing.   Propinquity gives rise to both benefits and dis-benefits – economies of agglomeration and scale, but also dis-economies of congestion and institutional overload.

A review of historical and epidemiologic data suggests that no unique logic can explain the diversity of observed patterns of urban health. Rather, health in urban areas is strongly linked – for good or ill – to the various processes inherent in urbanization itself, to the distinctly local social and systemic responses to these processes and finally to the quality of the natural, built and social environment. In the context of worldwide improvements in health indicators, urban areas stand out as generally healthy places, but are nonetheless characterized by strong social and spatial inequalities.

Yet, if urban change is universally transformational, it is not universally replicated: modern urbanization in the developing world is not simply a recapitulation of European experiences of the 19th century. Rather it is an original process in a quite different environmental, economic, historical and cultural context (UNCHS, 2002).   Moreover, even among regions which are socio – culturally and economically similar, 21st century urbanization retains a strong local and individual character, unique to the particular context. Thus, the challenge for researchers is to analyse the complex relationships between urbanization and health, to explore new health challenges under conditions of pervasive urbanization, to identify universal commonalities and local specificities in the urban experience of health, and, in the context of globalization, to recognize the growing interdependencies between far-flung cities.

Currently, there is limited understanding of the complex causal processes that shape urban population health and inequalities in health at local, regional and global scales. Food, nutrition, water, landscape, waste, transport, infrastructure, housing, energy, safety and security, access to health care and the urbanization process itself are interdependently linked to urban health, each influencing the other. Causes and consequences of wellbeing are woven in a complex web of social–cultural–technological conditions and associated human decisions. Running through all aspects of this picture are health and power inequalities and differential impacts along axes of human diversity such as age, income, gender, race, migrant status and social class. These interacting phenomena have always been with us, but they play out on an increasingly urban stage, especially in the developing world, where cities and towns are focal points in the search for environmental sustainability and economic development.

Urbanization is a complex process typically characterized by substantial social, ecological and environmental change, with health consequences that can be difficult to forecast.   Complicating efforts to address these factors are, on the one hand, the absence of an intuitive culture of public health among urban decision-makers, and on the other, the generally low awareness among epidemiologists and public health professionals of specific issues related to urban governance and planning.   In developing countries particularly, urban health and urban planning have developed along separate tracks (Harpham & Tanner, 1995).   In many parts of the world there are serious gaps in those systems of urban governance whose purpose is to facilitate improvements in urban health and wellbeing.

Policy makers – whether at global, national, regional, urban or community levels – who must daily make decisions that affect urban health and wellbeing, urgently require sound scientific evidence which reflects the complex matrix of issues, stakeholders, scales and, above all, competing interests. There is an urgent need to develop an innovative and operational approach to understanding urban health and wellbeing that integrates longer chains of causality and interactions between various different processes and factors. This, in turn, will help to integrate substantive consideration of human wellbeing into long-term planning, development and management of urban environments. Cities are, first and foremost, human habitat – not mere engines of economic production and

growth. Human experience and, in particular, human health should be a prime focus and rationale for how we build, extend, improve and run our cities.

The application of systems analysis can provide such understanding. A systems approach comprehensively considers all known and measurable aspects of a problem, including feedbacks that cross the boundaries of sub-systems and cut across scales; it acknowledges the nonlinearities and the dynamic nature of underlying processes, uncertainty and surprises. Importantly, it embraces an interdisciplinary methodology, integrating information from different basic and applied sciences and engineering with health information. It can enable policy-makers to cost, plan and examine different scenarios when evidence-based information may be incomplete and when controlled experiments cannot be performed.   A systems approach can identify important health issues for which scientific understanding or analysis are lacking and thus make an important contribution to improving health and wellbeing in today's urban environments while setting the future global health research agenda. As well, it can help to rank alternative policy responses, providing a platform for discussion and decision-making. It can, if properly applied, empower those who have traditionally been excluded from the decision making process by providing them with a powerful, yet transparent, tool for participatory dialogue and decision making for the urban context.

This document describes the rationale and overall framework for a proposed new ICSU interdisciplinary research programme "Health and Wellbeing in the Changing Urban Environment: a Systems Analysis Approach." It is targeted at the research community and other stakeholders. The preface described the background for the wider ICSU health initiative. Subsequent sections provide context on the changing urban environment and its implications for health and outline a conceptual framework for the study of health and wellbeing in and between urban contexts. Finally, guidance on research criteria and the use of a systems approach is offered to prospective investigators for the development of research proposals.

2. Context

2.1 Key concepts and definitions

In this section, key terms are defined as used throughout this document. Attention to these definitions is important at the outset as some of them can be subject to different interpretations than those adopted here.

Health: *A state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity.* (WHO, 1948)

This definition encompasses the basic elements intended to be addressed by a focus on health and wellbeing in the changing urban environment. This science plan refers to "health and wellbeing" both in its title and at various places throughout the text, to highlight health as a multidimensional concept that extends beyond the absence of disease. The physical components of health are clearly essential, including indicators of disease as well as physical disability or impairment of functioning. However, the behavioural and social components of health – mental disorders, mental disability or impairment, cognitive, emotional, and social functioning – are equally important. All three components are interrelated – physical health influences mental health and social functioning and vice versa. Research efforts that transcend the usual definition of health as the presence or absence of disease are to be especially encouraged under this programme.

Urban environment: *the natural, built and institutional elements that determine the physical, mental and social health and wellbeing of people who live in cities and towns.*

There is little if any consensus on how to define cities or towns; indeed, many countries have no formal definition of 'urban' at all. By urban, we mean areas that generally meet the criteria discussed in Box 2.1. Such criteria typically include a high density of people and structures with respect to surrounding non-urban areas, more complex economic and social organization, and a preponderance of non-agricultural occupations. Urban areas may be cities or towns and have distinct physical, social, and economic dimensions. Legal and institutional factors are important, as well, since the nature of land tenure, administrative rules, and taxation play an important role in defining what is urban and what is not.

While it is likely that much research carried out under this initiative will concern links between health and traditional environmental factors such as air and water pollution or exposure to infectious diseases, the urban environment is more than a physically defined entity. It includes the environmental and ecological context, psycho-social structures and supports, and patterns of migration as well as all aspects of the geography and politics of cities. Hence, governance arrangements, cultural identities and related activities, housing and urban form, education, food security, health services, land use and tenure, transport, water, crime and exposure to pollutants and extreme weather events are all dimensions of urban life that are properly included in a focus on health in a changing urban environment. The links between the immediate urban economy and those of the larger region and nation also play important roles in determining the physical, mental and social health and wellbeing of urban residents. Similarly, governance at wider scales, including internationally, has an impact on health and wellbeing in cities.

Box 2.1: Urban Terminology

The term urban environment implies that we know what urban is. In fact, there is no globally accepted definition of what constitutes an urban area (and thus an urban population) (Champion & Hugo, 2003). In most countries, settlements and their populations are designated urban or rural based on population size or density, physical characteristics, or administrative function (Van de Poel *et al.*, 2009). Of the 228 countries for which the United Nations has data, about half use administrative criteria, such as whether a settlement is a capital city, to classify it as rural or urban. About one quarter make classifications based on population size or density. The remainder uses a variety of other criteria, only some of which are explicit (Vlahov & Galea, 2002). Even among governments that use population size as a criterion for urban classification, there are significant differences. Some nations set a threshold for urban settlements at a population size of 20,000 or more; others use thresholds as low as 200 (Moore et al., 2003). Within countries, there is also variation the classification of urban areas. Furthermore, economic flows of goods and services along with daily flows of commuters tend to blur urban-rural distinctions in intra-country studies.

This document is flexible as to the precise definition of "urban", recognizing that it refers to concentrations of people, resources and processes in relatively dense agglomerations which have come, by custom or statistical definition, to be called "urban."

Urbanization is the process by which the fraction of the total population that is urban increases. It occurs in three ways: net migration from rural to urban areas, natural increase in urban areas, and reclassification of previously rural areas as urban. Globally, natural increase is the largest source of urban population growth, accounting for 60% of the total increase (Preston, 1979). However, rural-to-urban migration is the most significant driver of urbanisation per se (National Research Council, 2003). Rural-to-urban migrants tend to have greater fertility and hence raise the rate of natural increase in urban areas. In addition, the increase in population density resulting from migration and natural increase can lead to the reclassification of rural localities as urban. Within a particular country or region, urbanization can also result from immigration of rural or urban residents of other countries or regions, with potential health consequences, depending on source populations.

The level of urbanization is the proportion of the population residing in places classified as urban by the relevant civil authorities. Some social scientists use "level of urbanization" to refer both to the proportion of the population living in urban places and to the absolute size of the urban population. The rate of urbanization is the rate of change in the proportion of the population that is urban, properly given in percentage points per year for a particular period.

Formal definitions of urban and urbanization do not capture the growing importance of peri-urban settlements, which in many parts of Africa and Asia typically fall either under traditional authority control or a dual traditional/local government management system. Moreover, the term peri-urban is, perhaps, even less well defined than urban, as likely to be conceived in purely geographic terms as in social, economic, environmental or governmental – all elements which bear strongly on the character of such areas and the array of issues they face.

Work on urban health and wellbeing has often focused on informal settlements or slums, terms for which there is substantial conceptual overlap. Definitions have focused on the extra-legal, unplanned or temporary nature of such settlements, or on the relative or absolute deprivation experienced by residents. More concretely, urban slums have been defined by UN HABITAT in Millennium Development Goal 7/11 as urban settlements whose residents lack one or more of the following conditions: access to improved water; access to improved sanitation facilities; sufficient living-area, not overcrowded; structural quality/durability of dwellings; or security of tenure (UN HABITAT, 2003). From the health perspective, the essential element is deprivation and lack of facilities rather than legal status or informality of settlements: for example, some inner cities are formal settlements but suffer from extreme deprivation.

Systems analysis: *Analytic approaches that aim to understand the complex relationships among components of a system(s) including interrelationships between subsystems of a larger system. Such approaches explicitly account for interactions and feedback between variables or processes. The application of systems analysis in the framework of this science plan is particularly oriented toward seeking solutions to real-world problems in an explicit policy context.*

Systems analysis involves the use of mathematical modelling to represent processes and relationships and how desirable end points may be achieved. This science plan promotes this quantitative, policy-oriented approach from among the set of methods and models which also fall under the rubric of "systems thinking," some of which are more abstract or not oriented toward concrete outcomes. The former approach, emphasized here, clearly

reveals the interactivity between variables and processes, which are shaped by multiple factors. An appropriate systems analysis model should be interdisciplinary in nature and permit the integration of existing and new data and information, while leading to new insights and identifying gaps in current knowledge. It should enable reasonable scenario projections, which can be tested and refined experimentally. A complex system may be made up of several sub-systems, each of which might also be modelled separately. The appropriate linking of several models, based on an understanding of sub-system interactions, can give insights into the system as a whole.

A systems analysis approach will contribute to the comprehensive understanding of health and wellbeing in a changing urban environment. A number of conceptual and methodological issues will have to be resolved by any new programme aiming to generate products of use to the intended target audience (in particular, city planners and local or national policy-makers). Nevertheless, a systems approach can be the basis for a unique contribution that can reasonably be expected to inform city planning and related policy development in ways that will actually enable better decision-making.

2.2 History and trends[1]

Urban growth and transition

At the midpoint of the twentieth century, only 30 percent of the world's population lived in urban areas. Though data are imprecise, it is estimated that the world's population became predominantly urban sometime early in the 21st century – the United Nations estimates this demographic shift to have occurred in 2007 (Leon, 2008). Virtually all of the world's population growth in this new millennium is likely to take place in urban areas, much of this in Asia and Africa (United Nations, 2006). In the next 15 years, the world's urban population is expected to grow by 35%; it will add over 2 billion people over the next three decades, and, at the current rate of growth (~2% annually), double in just over 40 years, while the world's rural population will remain almost constant (Moore *et al.*, 2003). Complex regional differences in urban growth and change exist within these global averages. Rates of urbanization show a pattern of general slowing for all regions except North America (UNPD, 2001*b*).

A large fraction of urban growth in developing countries corresponds to growth of urban slums, which, in the last 15 years, has been unprecedented (Vlahov *et al.*, 2007). In 1990, there were fewer than three-quarters of a billion slum dwellers in the world. That figure has risen to approximately 1 billion today, and will reach 1.4 billion by 2020 if current trends continue (Lopez-Moreno & Warah, 2007).

It is the growth of smaller cities that will be most significant from a demographic standpoint. According to the United Nations Population Division, megacities – urban agglomerations of population 10 million or more – will account for only 12 percent of urban growth between 2007 and 2025. In contrast, cities of less than half a million will account for nearly half of the increase in urban population over the same period (Vlahov & Galea, 2002). Moreover, the geographic distribution of urban growth is often concentrated in those countries and areas where weak governance and under-development of urban government and institutions are most apparent.

Urbanization processes occur approximately in parallel with demographic transition: "In addition to becoming more urban, the world population is also becoming older and the proportion of older persons is expected to continue rising" (UNDESA, 2005). In some parts of the world, notably Eastern Europe and the historic industrial belt of North America, there is an absolute decline in the urban population and this too presents major challenges in managing health and well being. Nevertheless, despite the existence of models to explain transition in the context of urbanization, the main challenge is to recognize that this phenomenon encompasses not only demographic and urban dynamics but also unique developments for each city or town. Among other things, the coexistence of different stages of transition along different axes in individual urban areas is a factor that defies easy characterization.

According to UNEP, some of the negative environmental impacts of urbanization could be avoided by improving urban environmental management. "…However, urban growth is not yet well managed in most of the rapidly urbanizing areas, and this leads to major environmental and health problems, mainly associated with poverty" (UNEP, 2003).

The relationship between health, wellbeing and urban governance reflects shifting attitudes to both disease and planning. Prior to the twentieth century, ideas about the miasmatic character of disease spawned the physical separation of working class from upper class residential areas in an effort by the wealthy to protect their health. In the nineteenth and early twentieth centuries, the link between sanitation and infectious diseases, including cholera and influenza, among others, led to modern town planning and building regulations and the introduction of cross-subsidization for basic public services such as sanitation.

By the mid-twentieth century, with the introduction of cars and new building technologies, town planning shifted its focus away from concerns about urban health, focusing less on health outcomes and more on economic concerns. Urban sprawl and carbon-based construction materials are blamed for contributing to

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[1] The planning committee had the benefit of two IIASA reports undertaken with this initiative in mind: Cohen & Horlacher (2010) "Is urbanization good for a nation's health?" and MacKellar & McGreevey (2005) "Propinquity matters."

the shifting burden of disease of urban populations. From the 1980s there has been a resurgent interest in the interplay between urban planning and urban health and wellbeing. Nonetheless, the emerging body of research that demonstrates a causal relationship between particular diseases and urban form or urban management practices is still small.

Urban health and wellbeing

Urbanization is a process closely linked to economic development, but its effects on health have changed over time and can vary across urban environments. On the positive side, urbanization can imply improved access to modern medical technologies, health-care facilities, and highly trained health care professionals. City living generally provides improved education and raised per capita incomes that can – but do not always – translate into improved health (Bloom *et al.*, 2008). The "economies of proximity" associated with dense populations can reduce the costs of delivering infrastructure such as that required for clean water and social services. On the negative side, living in urban areas often entails greater exposure to outdoor air pollution, infectious disease, overcrowding, violence and crime, stressful work, social isolation, and risk factors for chronic disease, such as high-fat diets and a sedentary lifestyle. Moreover, as national wealth is increasingly concentrated in cities of the developing world, inequalities in health access and outcomes in cities and between cities and rural areas have only increased.

In medieval and early modern Europe, urban areas were consistently associated with poorer health and higher mortality rates than rural areas. This phenomenon, known as the "urban penalty," (Kearns, 1988) was primarily attributable to communicable disease resulting from overcrowding, poor urban sanitation, and lack of access to clean water and waste disposal. Millions living in cities died in epidemics of influenza, typhus and tuberculosis. Life expectancy was as much as fifty percent higher in the countryside than in larger towns and there was a clear mortality gradient from city centres through the less populated outskirts to surrounding rural areas (Freudenberg *et al.*, 2005).

In most countries today, health is typically better in urban than rural areas. This difference is largely attributable to the adoption of public health measures and other interventions (e.g. antibiotics, vaccines, medicines, sanitation, water treatment, improved nutrition and information systems) that have led to a declining prevalence of infectious diseases (with some exceptions, such as dengue fever). However, urbanization today is associated with adoption of lifestyles that favour the development of chronic non-communicable diseases (Poel *et al.*, 2009). Increased consumption of salt and energy dense foods, reduced physical activity, increased tobacco use, psychosocial stress and isolation have led to an increased prevalence of risk factors – e.g. hypertension and obesity – which in turn have lead to increases in heart disease, stroke, certain cancers and diabetes (Mendez & Popkin, 2009). In fact, growth of the world's urban population is a major driver of a projected increase of more than 50 percent in the global prevalence of diabetes (Wild *et al.*, 2004). Nevertheless, mortality from chronic non-communicable diseases is generally lower in urban areas than in rural areas because of better access to diagnostic and treatment facilities (Wild *et al.*, 2004).

Today's urban environments are also characterized by increasing health differentials within cities, as well as between wealthier and poorer cities. Although health, on average, has improved in urban areas, those urban poor that live in slums or in marginalized situations may experience such inadequate living conditions that their health outcomes are even worse than those observed in rural areas (Kyobutungi *et al.*, 2008, GRNUHE, 2010). The urban poor often face inadequate housing and sanitation, lack of running water, poor or under-nutrition, overcrowding, indoor pollution, substance abuse, violence, loss of social support, poor access to health care, increased vulnerability to extreme temperatures or climatic events such as flooding or drought, and lack of participation in decision-making (UNDP, 2010). Many of these conditions are not unique to urban areas; it is nonetheless clear that they negatively impact health and wellbeing and markedly increase risk for many urban populations. Although questions of poverty and social inequalities related to urban life are relevant to health and wellbeing for countries at all levels of development, they are particularly important to consider in many urban settings in less developed countries (Environment and Urbanization, 1999).

Some urban environments face particular challenges associated with migration, informal settlements, food insecurity, job insecurity, long-term and emerging conflicts, emergence or resurgence of infectious diseases, and massive environmental degradation. The latter is particularly prevalent in countries where economic growth has occurred at an extraordinarily rapid pace and large scale. Many cities are highly-reliant on fossil fuels for energy and are important sources of greenhouse gas emissions, which are a major cause of global warming (IHDP, 2005). Climate change will affect health in cities in a variety of ways (e.g. increased frequency and severity of heat waves, flooding and inundation, food insecurity, potentiation of transmission of some infectious diseases, exacerbation of certain urban air pollutants, increased migration). All these factors, both individually and in combination, are likely to negatively impact the health and wellbeing of urban populations, often for prolonged periods.

2.3 Governance, finance and decision-making

Urban health and wellbeing is shaped by many "managerial" factors, including formal and informal policies, budgetary and regulatory decisions made at global, national, city and local scales as well as negotiations over access to power and services that may enhance or detract from urban health and wellbeing. A systems

analysis, in this context, could capture and model these complex relationships to reveal the drivers of urban health and wellbeing and, through an enhanced evidence base, make the impacts of policy and budget choices more transparent. Because systems of urban governance are context- and history-specific, varying among cities, countries and cultures, systems modellers need to work with, local communities, social scientists, health specialists and policy makers to fully understand the urban governance context and ensure the shared scientific and policy legitimacy of data that is produced, collected and distributed.

International policy positions are very influential, especially for national governments called upon to endorse global targets relating directly or indirectly to urban health and wellbeing. National governments often control key aspects of fiscal and regulatory environments that strongly influence urban health, such as welfare, transport, energy and water. However, the decisions with the most direct impacts are often taken by local governments. Notwithstanding the tendency towards decentralisation, the distribution of powers and functions across government and the associated budget allocation does not always permit local autonomy over urban-health-based decisions, making intersectoral cooperation critical. Cities do not act alone – decisions by civil society and business also affect urban environments and hence health. Thus, governance decisions are taken at local, municipal, national and global scales by a wide range of entities, organized along different axes and possessed of different goals and priorities. Similarly, health decisions are made by actors at different levels – individuals, health care providers, local, regional and national officials, and so on up to the global scale.

It is important to identify participants in decision-making at all levels, to understand the power structures within which they must act, and to identify their options and any constraints on their actions. In particular, information and access to information play crucial roles in decision-making. Systems analysis modelling may need to incorporate relevant information from a variety of appropriate inputs, including official and academic data sources, as well as less formal sources. Participatory research methods, in both the collection and inclusion of data on urban health and wellbeing, can be especially effective in analysing the social determinants of health.

Decision-making inherently implies priority-setting, necessitating trade-offs between competing interests and a long-term vision – goals which can be profitably addressed through a systems analysis approach. As many decisions that enhance urban health and wellbeing are intensely political (e.g., alcohol regulation, incentives for pedestrian-friendly cities, relocation of informal settlements) researchers must be cognisant of vested interests to ensure that scientifically sound policy analysis and advice can be produced and disseminated. In urban contexts where the underlying data is weak or patchy, particular care to ensure legitimacy and transparency of the systems model inputs and outputs will be necessary.

International policy context

A number of important policy documents frame current understandings of the urban health and wellbeing agenda and define the corresponding governmental commitments. The Alma Ata Declaration of 1978, which established the "Global Strategy for Health for All (HFA) by the year 2000", was the first policy document to underscore the linkages between health and living conditions and to emphasize the importance of participation and inter-sectoral action in reducing health inequities. A number of more recent policy frameworks and commitments – including the Millennium Development Goals (MDGs) (2000), the WHO Commission of the Social Determinants of Health's report *Closing the Gap in a Generation* (2008), the International Covenant on Economic, Social and Cultural Rights (ICESCR) (1976), and the World Health Report *Primary Health Care; Now More Than Ever* (2008) – similarly emphasize the multi-dimensional nature of poverty, the connections between health and social conditions, and the importance of cross-sectoral social interventions and participatory processes in addressing the root causes of health inequity.

In the urban policy community, there is a growing awareness of the need to improve individual and collective urban conditions. Of critical importance is the UN HABITAT-sponsored global commitment to promote the eradication of slums. The 2009 *Global Review on Human Settlements* (UN HABITAT) reflects a resurgent interest in urban planning, including from a health perspective, clearing the way for a more integrated approach to urban governance that lends itself to systems analysis. Most recently, the 2010 World Urban Forum in Rio advanced the idea of a global commitment to "the right to the city," in which fundamental human rights, including those to health, are advanced not just for individuals, but across the urban environment. The "right to the city" is a significant departure from earlier shelter- and basic service-based policy positions. It allows a much more comprehensive approach to urban health and wellbeing because of a shift in focus beyond individuals and instead on the holistic functioning of neighbourhoods and the city as a whole. In this regard, there is apparent convergence between the health and climate change agendas, with the possibility that a future UN Climate Change protocol will speak directly to the planning, development and management of cities (Haines *et al.*, 2009).
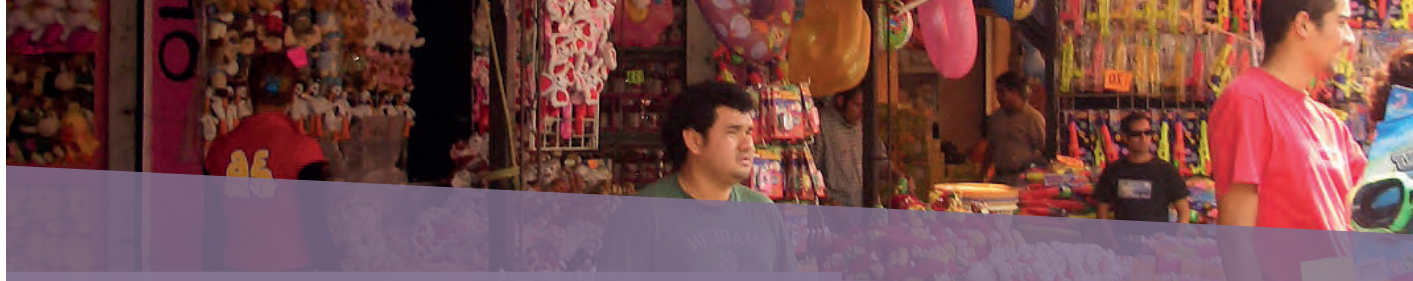
3. A conceptual framework for health and wellbeing in the urban environment

The study of health in an urban environment requires consideration of a wide range of factors and conditions, acting and interacting at various scales. This research programme is designed to take the broad and integrative view. The particular characteristics of a city – cultural, economic, environmental, geographic, historic, political, and social – vary widely, even across cities within countries. So do the ways in which these factors influence and interact with human health and wellbeing. Among the few urban constants of today are complexity and rapid change (e.g. as a result of internal migration or globalization).

In Fig. 3.1, we illustrate a framework in which the complex relationships among factors influencing health in urban contexts can be considered. This framework is broadly similar to that defined by the WHO for Social Determinants of Health in urban settings, but contemplates a wider set of influences (WHO, 2008). Health outcomes – physical, mental, or social (represented at the bottom of the figure) – are shaped by *proximal* elements acting directly on individuals and *distal* elements acting indirectly at municipal, national and global levels.

Reality is considerably more complex than any such figure can convey, with long chains of causation wherein one factor influences another to eventually affect the health of individuals and communities – thus the terms *proximal* and *distal* can be thought of as defining the endpoints of a continuum of proximity. Nonetheless, this dichotomy is useful for better defining variables for a systems approach. Systems analysis, in turn, allows us to better understand the convoluted chains of elements that affect urban health and wellbeing.

Determinants of urban health and wellbeing can be grouped into thematic classes, each of which has elements that act both proximally and distally. At one end of the spectrum, proximal determinants include those biologic, behavioural and environmental factors that help to determine an individual's baseline risk, including, for example, genetic makeup, nutrition, high-risk or preventive behaviour and living conditions. In general, factors that can be considered *compositional* – arising from differences in the individual characteristics of the residents – tend to act proximally. Such factors often appear to be grounded in individual choice or behaviour, although in practice they are frequently conditioned by prevailing values, opportunities and economic pressures/incentives.

At the other end of the spectrum, distal determinants influence health indirectly, and include such factors as the natural and built environments, food and energy production, economics, educational and employment opportunities, political systems and governmental regulation, family and culture, and factors that affect the capacity or empowerment of individuals or communities to affect their health. Factors that can be thought of as *contextual* – arising from differences in the social and physical environment – tend to act distally. National and global trends, such as decentralization, devolution, privatization, immigration and globalization, as well as enduring structures and values such as religion, economic and political systems, all influence health in urban areas and the distribution of health within and between cities. Many of these distal factors are of a more 'ecological' kind and impinge on whole communities or groups. [Note, the health determinants shown in Figure 3.1 are not an exhaustive list and the reader may be able to identify other proximal and distal factors that are important in particular urban settings.]

At all levels of proximity, health determinants can act *synergistically* or *antagonistically* to multiply or diminish observed effects. Moreover, the complex interplay of determinants can produce effects at the *individual* or aggregate level. For example, taxes on processed food and subsidies on farmers' markets could act synergistically to promote increased fresh fruit and vegetable consumption. In contrast, tax breaks to small businesses that increased numbers of fast food restaurants could offset efforts to subsidize farmers' markets. In the same vein, increasing the price of infant formula could have a synergistic effect, promoting breast feeding whereas providing free formula to new mothers might reduce the initiation and duration of breastfeeding. These effects could arise at the individual level of parental behaviour, or at the aggregate level, influencing the behaviour of the business, agricultural and consumer communities.
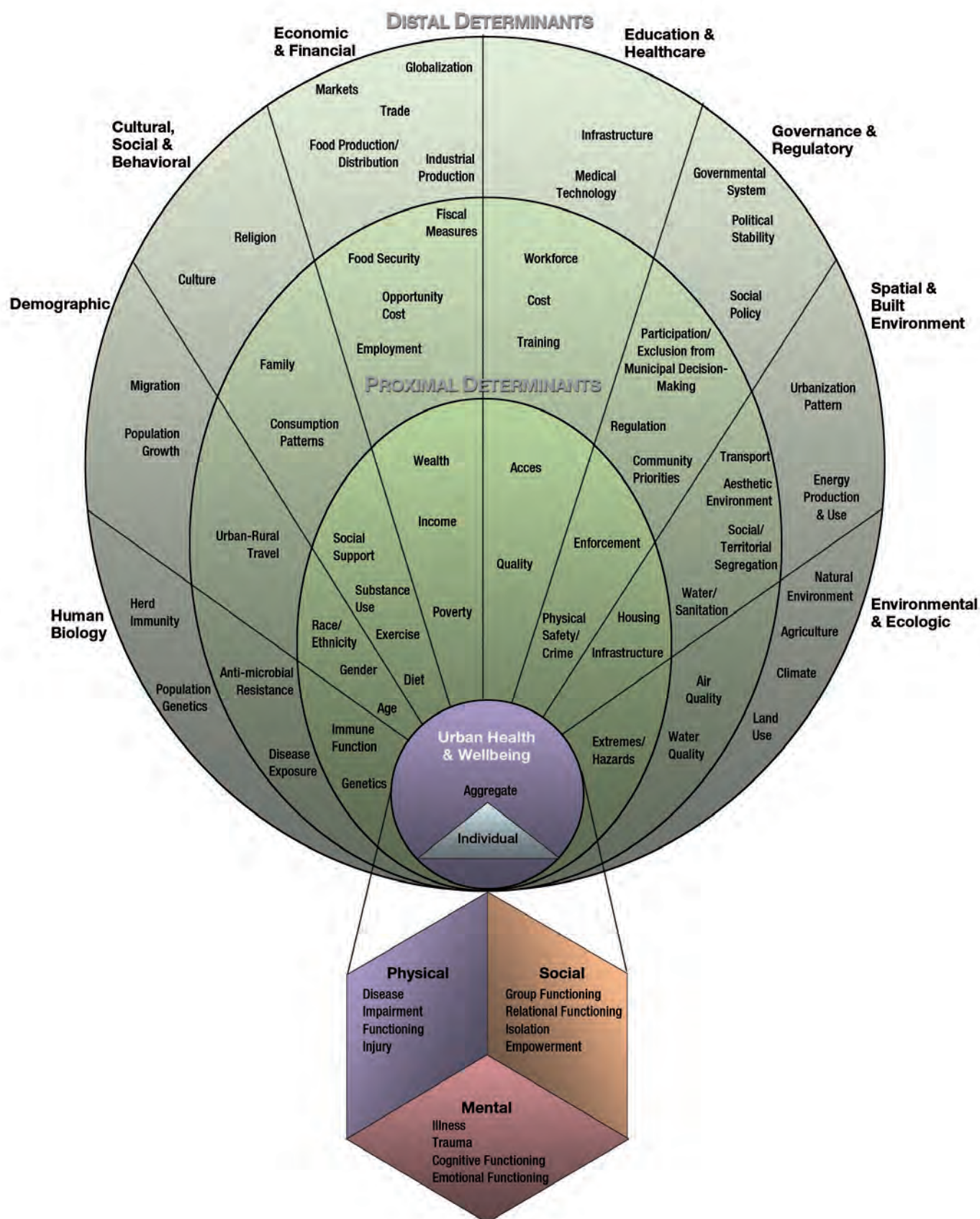
Figure 3.1 : A conceptual framework for the determinants of health and wellbeing in the urban environment.

Physical, mental or social health outcomes can themselves affect the occurrence and distribution of sets of determinants, through positive or negative feedback loops. Further, many health outcomes are consistently linked with each other and are thus referred to as *co-morbidities;* for example, many patients suffer simultaneously from obesity and diabetes and depression. Grmek (1969) argued that diseases should be studied in relationship to one another and introduced the concept of *pathocenosis*, which proposes that the existence and spread of any specific disease depends on the existence and spread of all other diseases in society.

Certain diseases persist at a stable level in a particular society as a result of particular environmental and cultural factors; the introduction of new factors can change disease patterns within a society. Syndemic is a related concept in which health-related problems cluster for particular reasons (Singer, 2003). For example, the first syndemic to be described consisted of violence, substance abuse, and AIDS in poor inner-city populations facing an array of political-economic and social challenges – unemployment, poverty, substandard housing or homelessness, poor nutrition, disrupted family and social relationships and little or no access to health care (Wallace, R., 1988; 1990; Wallace, D., 1990). Obesity, diabetes and depression might be conceptualized as a syndemic associated with lack of exercise, poor nutrition, poor education and culture. To prevent or reverse a syndemic, one must prevent or control the forces that tie the co-occurring conditions together.

The framework presented here is intended to emphasize the fact that no single element or determinant acts in isolation or at a single scale. Rather, human health and wellbeing in the urban environment depends on the sum total of the interactions between and among determinants and outcomes. This complex interplay of factors can be well-accounted for through the use of a systems analysis framework.

4. Systems analysis

4.1 The role of systems analysis

This programme aims to encourage systems analysis of real-world problems with a view to improving understanding and decision-making on health and wellbeing in the urban environment.   This research will be developed in the context of a close collaboration between researchers of different disciplines and other relevant stakeholders.

What makes systems analysis a uniquely appropriate approach? Where does its added value lie?

- It is integrative and inter-disciplinary.
- It incorporates feedbacks.
- It identifies constraints and incompatibilities.
- It differentiates between critical and unimportant elements and relationships.
- It incorporates inter-relationships between individual elements.
- It reveals or incorporates non-linearities.
- It highlights the roles of collective action and stakeholder involvement.
- It highlights unpredictability and uncertainty.
- It alerts us to potential unintended consequences.
- It makes explicit the dynamics of the system.
- It promotes the development of comprehensive databases and advanced computer technology.
- It lends itself to cost-effectiveness analysis.
- It can provide predictions even when data are sparse.

Systems analysis is necessarily linked to the use of analytic models, typically deterministic or stochastic/ probabilistic models that are solved on a computer (see Box 4.1 for some examples of modelling approaches). Such models are never, in a sense, "true," – that is, they never incorporate the full complexity of reality – in fact, the purpose of developing a systems model is to simplify reality for the purpose of aiding understanding and developing a plan for acting on the system. They are particularly useful for their heuristic value – for general forecasting rather than point prediction. It is worth noting that in the absence of formal models, scientists and policy-makers rely on informal mental models, which also have flaws; the difference is that mental models are opaque and not open to exploration, whereas formalizing models requires that they be transparent and open to examination. A well-defined model that incorporates the most salient aspects of a problem is thus an invaluable tool in decision-making. The discipline imposed by the formal mathematical logic of these models can, at a minimum, assist in identifying and eliminating inconsistent or unfeasible policy options.   At their best, when they can be iterated and refined over time through comparison with available data, and particularly when they span disciplines, models can generate genuine insights; for example, models originally developed in economics (game theory) were adapted for use in biological research (evolutionary ecology), where the results were so impressive that the resulting models were re-adapted to use in economics (Levin, 2006; Beck, 2009). The development and use of models can also serve as a process through which researchers from relevant disciplines can communicate and collaborate.

Many readers of this science plan will know of approaches other than those in Box 4.1 – the intention here is not to be exhaustive, but to lay the groundwork for major points involving tradition, linkage and scale, and to highlight the application of the approach to the urban context. The GEO-Unions of ICSU have already worked on

assembling a comprehensive list of models falling in their purview (see Box 4.2), and similar cataloguing efforts would prove useful in other areas. Innovative methods that build on the traditional approaches in Box 4.1 are especially encouraged. The first step towards modelling more complex systems is often to link simple approaches – the results of such efforts are often surprisingly filled with insights.

Box 4.1: Examples of relevant modelling approaches

- Population projection models, traditionally cohort-component models but increasingly multi-agent micro-simulation models. Application to urban health: projecting target populations.

- Economic growth models, traditionally based on factor accumulation and ordinary differential equations.

- Models of the composition of output, traditionally input-output or general equilibrium models. Application to urban health: projecting demand for health care and fiscal resources.

- Urban form models, traditionally based on cost minimization and the bid-rent curve according to which rents decline with distance from the centre of economic activity. Application to urban health: input to optimization models of health facility distribution.

- Urban flow models, traditionally gravity/spatial interaction models in which different nodal points have "mass" and different modes of transport between nodes have costs. Application to urban health: modeling trips to facilities, typically as part of optimization model of health facility distribution.

- Engineering models of the production, dispersion, and accumulation of pollutants in the urban environment. Urban air pollution models and models of urban water infrastructure and supply are obvious examples. Models of urban ecology and industrial metabolism are also approaches that have been used, and emissions of pollutants have been incorporated into urban input-output models. Urban pollution exposure models incorporate the distribution of pollution in microenvironments and the movement of urban residents to estimate individual exposure.

- Engineering approaches to control and optimization of non-linear and multi-scale models.

- Models of pollution and development, traditionally revolving around some form of the so-called Kuznets curve or the Impact-Population-Affluence-Technology model. Application to urban health: modeling long-term changes in pollution.

- Models of vulnerability to natural catastrophes. Data series of natural events, combined with engineering data and the performance characteristics of structures, can be used to calculate the vulnerability to extreme events. Applications to urban health: modeling impact of extreme events; stochastic modeling of health system vulnerability and resilience.

- Models of human health. At the individual level, these include frailty or time-to-failure models. At the macro-level, prevalence and incidence rates have traditionally been modeled as functions of income, education and the like. The medical tradition of modeling, e.g., cardiovascular disease as a function of smoking and obesity, practically underlies the field of biostatistics. Pharmacokinetic and pharmacodynamic models have examined drug effects and interactions and metabolic pathways in individuals and populations. Structural epidemiological models of the Susceptible-Infectious-Recovered (SIR) tradition have offered means of modeling infectious disease. Urn models from classical probability theory have been a rich source of applications to infectious disease. Micro-simulation models, however, have increasingly been the tool of choice in epidemiological modeling.

- Health systems have been traditionally modeled in several ways. Health system planning has often been done on the basis of fixed patient-provider, patient-machine, or patient-facility ratios to estimate needs and identify bottlenecks.

- Systems Dynamics models.

- However much this programme values the use, extension, and combination of traditional approaches, it is equally devoted to encouraging new and innovative ones. Complexity science – in the form of endogenous spatio-temporal heterogeneity of social processes – new economic growth theory, incorporating human health, agent- and network-based modelling, multi-scale data analysis, new techniques for mapping and real-time visualization, and other innovative modelling techniques may prove essential to advancing understanding.

For example, integrating methodologically standard projections of changing demographic structure and residential patterns with equally standard health care needs projections would allow for improved urban health policy design. Many approaches may be traditional at the aggregate scale (for example, national health accounting) but novel at the urban scale. An analogy may be found in the then-novel application of national input–output modelling approaches to urban areas in the mid-1960s.

Influence (flow) diagrams (as illustrated in Fig. 4.1) constitute an effective means for visualizing the components used to construct systems models, linking simple observed relationships to produce more complex and realistic representations, and communicating insights about the implications and potential outcomes of analysis. Properly developed, they can illuminate complex real-world dynamics, thus providing a framework for systems analysis.
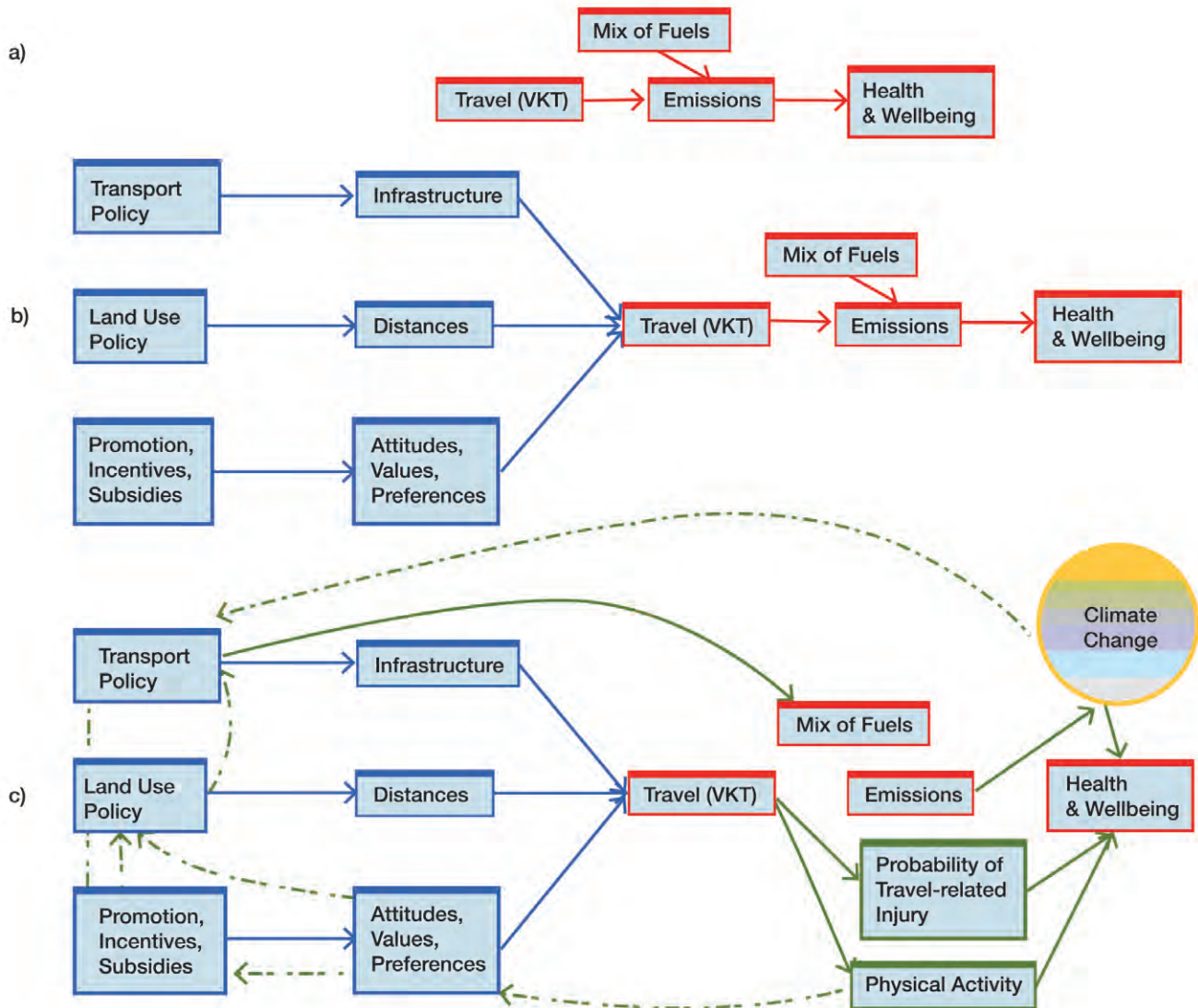

Figure 4.1: Progressive development of an influence diagram: Blocks of text represent system variables and arrows show influence links. a) shows a simple model of how vehicle use affects health and wellbeing *via* the release of emissions (VKT = vehicle kilometres travelled); b) builds on this simple model, explicitly incorporating urban policy options, illustrating longer chains of causation, and showing how various options available to urban policymakers (in blue) might affect vehicle use, and thus health and wellbeing; c) adds a new layer of complexity by including additional pathways by which travel affects health and wellbeing and feedback loops (in green), as well as links to another complex system (climate change, in yellow), which interacts with the urban system *via* multiple pathways. Defining the main system variables, influential relationships and feedbacks allows these to be more easily conceptualized and incorporated into a systems analysis model. N.B.: while some of these key factors are depicted for illustrative purposes, this figure is not intended to be comprehensive.

Figure 4.1 does not claim to illustrate every important relationship between individual variables – other pathways can easily be identified. Nevertheless, the progressive addition of complex elements to the simple model and, crucially, the identification of which elements are essential to a satisfactory understanding of a system, are important initial steps in systems analysis. Among the central features of the formal analysis resulting from such models are the ability to "experiment" with changes in any of the model parameters and observe the effect of such changes on health and wellbeing and, in turn, what this implies for urban policy, and the ability to identify sensitive relationships and points of influence, where small changes can have important consequences.

Working through the common language of mathematics, we are more likely to achieve integration across disciplines. Ideally, interdisciplinary modelling projects should empower researchers to move across disciplines, communicating easily in the shared language. In addition to the horizontal integration of disciplines, vertical integration – from the modelling community to primary field scientists and, ultimately, to the decision-maker or lay person – is also needed. Transparency about the essence of the model is crucial to the building of trust among these communities. Trust and legitimacy are only likely to be attained when the basics of how the model works, the assumptions that go into it, and the resulting uncertainty and limitations are broadly communicated and understood.

Box 4.2: Cataloguing models and data sources

An awareness of existing models and data sets is fundamental to the design of any research project involving systems analysis. The more complex the system, the more difficult it can be to identify the most relevant models and data. The Geo-Unions of ICSU have started an initiative to catalogue, describe and reference the models used by their disciplines which are relevant to the study of health and wellbeing. This catalogue includes over 150 entries. In collaboration with the ICSU Regional Office for Africa, this initiative has also carried out a preliminary analysis of health data sources in major cities in 16 African countries. Whilst this initiative is at an early stage, there is obvious potential for some of these techniques and data sources to advance current modelling approaches and provide insights into the determinants of health and wellbeing in urban areas in Africa.

4.2 Data challenges

The overall goal of this research programme is to produce and apply models of health and wellbeing in the urban environment that simultaneously advance our understanding of the origins (i.e., causation) of the problems and potential solutions in this area and which can therefore inform decision-makers. In doing so, a number of challenges and limitations must be considered. Among the most important of these are deficiencies in data quality and availability, data linkage, and data confidentiality and ethics.

The complexity and management of urban environments far outstrips the availability of data for implementing a complete systems approach to urban health, especially in rapidly growing and poor cities. Research addressing gaps in data quantity, quality and comparability is urgently needed. Of particular importance in addressing determinants of health in urban settings is access to information on health disparities, as well as contextual information about the social, physical and institutional environment in which urban health is embedded. Without this information, it is difficult to prioritize actions, and virtually impossible to draw conclusions about resulting changes (positive or negative). There is also a need for more and better information about urban governance and health care to assess performance and enhance accountability.

As important as information itself are the methods by which it is generated, the users by whom it is applied, and the uses to which it is put. The large amount of data produced by governments and an increasing number of health agencies do not always comprise comprehensive and relevant information for users. A fundamental issue is the collection of relevant, standardized and accessible data, particularly in cities of the developing world.

Among specific data needs are:

- Information on changes in health status as individuals and families migrate from rural to urban areas

- Data on health differentials across different types of settlements and governance regimes in urban areas

- Data regarding diseases specific to urban areas

- Health statistics disaggregated on an intra-urban basis – which would facilitate research on health, treatment seeking, and health services quality in urban slums

- Data (urban and health) disaggregated by socioeconomic groups

- Finance data relating to urban health

- Ready access to multiple data sets of behavioural research

- Transformation of discrete data sources to become part of publicly accessible data sets

- Appropriate data management and policies.

There is a related need for studies that generate and compare data that would be of broad utility, including:

- Area-based panel studies that examine health issues over time in gradually urbanizing rural areas – to deal with the problem of health-selective rural to urban migration, these panel studies should follow the health

outcomes of panel members who migrate out of the study areas

- Comparisons of data from countries with similar definitions of rural and urban areas – the lack of standardized definitions of urban versus rural residence across countries is a major obstacle to cross-country comparisons

Even where data exist, they are not always readily available for research. Data accessibility is largely a product of data management practices and data policies. Both of these areas have been the focus of recent ICSU reviews and activities (ICSU, 2004). Whilst not specifically focused on the urban environment, the generic conclusions are applicable here. ICSU has a declared objective of playing "a major role in promoting professional data management and fostering greater attention to consistency, quality, permanent preservation of the scientific data record, and the use of common data management standards throughout the global scientific community" (ICSU, 2004). Data stewardship must be an important element of the urban health and wellbeing science plan.

ICSU's overall policy on data access calls for full and open access, with some allowance for limited restrictions relating to issues such as personal privacy and security. ICSU and its associated bodies have played an important role in promoting both good data management practices and policy within the intergovernmental initiative to develop a Global Earth Observation System of Systems (GEOSS, Box 4.3). Linking with initiatives such as GEOSS can potentially play an important role in providing a framework to improve the accessibility of data relevant to urban health.

Box 4.3: The Global Earth Observation System of Systems (GEOSS)

GEOSS is an intergovernmental initiative to develop a coordinated and comprehensive earth monitoring system. It is being built on thousands of already existing ground, airborne and space based instruments and will also incorporate new monitoring structures. One of the nine selected societal benefit areas that are shaping the development of GEOSS is health, with the stated aim of improving understanding of environmental factors affecting human health and wellbeing. Specified end-products that GEOSS is expected to contribute in relation to health include decision support tools for the policy community. It is intended that the large majority of the monitoring data collected by GEOSS will be available for academic research and this should provide an invaluable resource for the current programme. However, the current GEOSS work is largely focused on ecosystems, with little, if any, urban-scale applications; moreover, the bulk of the research and data comes from and informs processes centred in the countries of the developed, rather than developing world. There is an important opportunity to influence the long-term nature and focus of GEOSS by identifying routine monitoring and data collection needs for urban health research.

Issues of data linkage comprise a second major obstacle to research. There is general agreement that human health and wellbeing are the products of a complex interaction of genetic and environmental factors, nutrition and other lifestyle behaviours, infectious agents and stress (Weiss *et al.*, 2005). Etiological research is ideally conducted on an individual-level basis – diseases occur in individuals and result from an individual's genetic characteristics, exposure to pollutants, nutrition and physical activity, access to quality health care, etc. Yet, this type of individual-level analysis is rarely feasible. When health and environmental data are routinely collected, they are rarely linked at the individual level.

For example, a country may collect and report health statistics for a variety of diseases. It may also collect and report a variety of other statistics such as high-school graduation rates and unemployment statistics. It may further document how many people live in urban versus rural environments and conclude from an examination of these data over time that the rural population is declining through migration to urban environments. However, these data are often available only for the country as a whole or for large regions of the country and are not linked at the individual level. Such data permit only crude associations between health statistics and other variables of interest and can never capture the complex interaction between biology, human behaviour and the environment. Data collection systems that permit linkage at the individual level would often be ideal. However, some have suggested that small area studies that tag data spatially in small geographical units (e.g. neighbourhoods, zip codes, census enumeration areas) may be more feasible and very useful, especially when geographical units have very low within-unit variability and great variability across units (e.g. income varies very little within the neighbourhood unit but there are large differences between neighbourhoods) (Elliott & Savitz, 2008).

A third set of challenges arise from questions of data confidentiality and ethics. Ethical issues likely to arise in work on urban health and wellbeing are generally similar to those working with communities at all scales, However, there may be additional issues of data confidentiality and sensitivity that emerge at the urban or neighbourhood scales owing to political sensitivity or potential financial impacts. For example, some governments are reluctant to collect or release data relevant to their regional jurisdiction and may not want to engage or enable interregional comparisons.

As in other health and wellbeing research, the use of personal health data in particular may raise concerns about privacy and confidentiality. In 2004, ICSU carried out a broad strategic assessment of generic issues and needs for *Scientific Data and Information* (ICSU, 2004), which provides a number of relevant recommendations and/or guidance.

The assessment paid particular attention to issues of privacy and security. It noted:

> The ease of combining or integrating electronic research data obtained from multiple sources heightens the need for protection of individual, national, and corporate privacy and confidentiality in scientific databases. By combining data from multiple sources, the integration of various data sets for research may reveal previously private information on individuals, states, and companies. Both research and management of data on human subjects require special procedures so that individual privacy and confidentiality are not violated. In many countries, the privacy and confidentiality of scientific data and information are subject to legal regulation and restrictions. But national legislation or regulation of data privacy differs from country to country and scientists conducting research projects that involve residents of multiple countries may have to respond to multiple types of privacy and confidentiality restrictions covering the same data set. Developing countries, in particular, often have no, or very limited, regulations on personal data use, which can make the data particularly vulnerable to abuse.

In summary, there are very significant data challenges that require appropriate practices, policies, infrastructure and investment. These challenges should not be underestimated. However, most of them are not unique to the urban environment and many have been addressed in other areas of research. A combination of existing and novel solutions and approaches and effective linking with initiatives such as GEOSS should enable them to be addressed over time. Addressing data needs and identifying gaps should go hand in hand with the development of systems analysis capacity and methodologies.

5. What kinds of research is the programme designed to encourage?

5.1 General criteria

Research under this programme should address, within an inclusive and multi-level 'ecological' frame, major health risks or outcomes associated with the (changing) urban environment. Relevant topics should be amenable to systems analysis and, importantly, the analyses and interpretation should facilitate policy responses.

Projects should identify anticipated long-term impacts, including policy implications and potential for strengthened research and decision-making capacity. The general criteria that are proposed to define research projects suitable for inclusion in this programme are listed in Table 5.1.

Table 5.1: General criteria for research projects	
Study element	**Requirements and description**
Study focus	Projects must focus on **health and wellbeing** in, and as influenced by, the **urban** environment.
Scientific team	Projects should be **inter-disciplinary,** including collaboration across scientific disciplines, from medical, physical and social sciences and engineering.
Process	Projects should be **collaborative**, engaging multiple stakeholders, including, as appropriate, policy makers, local government, and the community.
Method	Projects should make use of the methods of **systems analysis,** adopting an explicit model, defining and describing the relationships among multiple variables, and making predictions of real-world impacts. Models that integrate variables from different sectors or disciplinary approaches are particularly encouraged (methodology and data sources will be transparent and documented).
Variables	Models must link **health and wellbeing** with one or more **determinants of health**. All variables must be well-defined and specify how they will be measured or assessed. Proxy variables of health, when used, should be clearly related to health.
Feasibility	Project proposals should credibly establish that needed data are **obtainable**. In particular, procedures and/or agreements to obtain the data necessary to conduct the systems analysis should be described.
End-users	Projects should have clearly defined end-users, who are likely to include (but are not necessarily limited to) some of the multiple stakeholders involved in the project design and implementation, re: Process criteria above.
Products	Projects should produce **scientifically sound policy-relevant research findings**.

Study Focus. All projects must focus on health and wellbeing in the urban environment. The research programme encourages studies that focus on indicators reflecting a multidimensional conceptualization of health and wellbeing. Study investigators must define the urban environment(s) in which their study will be conducted. Retrospective, as

well as prospective studies are welcome. System boundaries should be explicitly identified. Studies should be framed in ways relevant to the decision-making process. It is envisaged that the programme will include projects that address urban challenges in a wide range of cities of various sizes and in various regional and global contexts.

Scientific Team. The research project should take an interdisciplinary approach, engaging researchers from multiple fields to create and apply knowledge. Interdisciplinary teams of researchers in the natural, social, engineering and biomedical sciences are particularly encouraged, as are North-South and South-South collaborations. Where projects in the developing world include local research partners they should be involved in all aspects of the research process, including publication outputs.

Process. Research must involve collaboration between the scientific team and other stakeholders. The purpose of this initiative is to make the results of a systems analysis of health and wellbeing in the urban environment available in usable form to those stakeholders whose actions will influence health in this setting for years to come. As such, a collaborative approach which includes engagement with multiple stakeholders is required. Stakeholders will vary regionally and even within countries, and are not limited to those directly responsible for city governance and city planning, but might include elected and appointed officials, the private sector, the research establishment and civil society organizations and other community-level non-state actors, including consumers and their organizations. The domains in which these players act are diverse, but include planning (e.g. urban, transport, land-use), management and service provision, environmental protection, and health promotion.

The needs and challenges of target stakeholder groups are an important input to systems analysis. Identifying these needs and challenges requires answering questions such as: What information do planners and policy-makers require to assist them to achieve or maintain health and wellbeing in their cities? What information have they found useful? How are issues framed? Who sets the agenda and who can make enforceable decisions? What constitutes informed choice by planners, policy-makers and community participants? The resultant output from systems analysis can in turn inform urban management policies, as well as identify needs for further work and new directions, with the ultimate goal of improving human health and wellbeing.

Method. The research project must incorporate the methods of systems analysis, including the use of quantitative models to address explicit policy-relevant outcomes. Models should account for the inherent complexity of the urban environment and at a minimum, should include multiple determinants of a single health outcome or a single variable with consequences for multiple potential health outcomes. Studies which incorporate multiple indicators from multiple domains are likely to be especially relevant, because the power of systems analysis lies in its ability to capture the complex determinants of human health.

Unidirectional studies estimating the impact of change in one variable on another variable are less appropriate under this programme than studies that also take multivariate (and perhaps multi-level) causality, interactive and feedback processes and the possibilities of reverse causality into account. A proposal to study the impact of health on income in the urban setting, for example, would be much stronger if it explicitly took account of the feedback effect of income on health.

It is clear that location, micro-environments, and the flow of humans across urban spaces play an important role in urban health. Consequently, spatially comparative studies or those with clear geospatial applications are likely to be of greater interest than studies in which there is no spatial dimension. This would include studies based on individual, community, and policy-actor perceptions of relevant space and scale.

Studies taking into account complex relationships among health conditions are also encouraged. For example, both urban transport systems and neighbourhood safety may be linked to obesity, depression, and diabetes. Effective studies might link transport and personal mobility models to biological models that in turn link energy expenditure (for given calorie input) to weight. Similarly, studies that include intergenerational transmission of health would be of interest. For example, breastfeeding may be a product of cost and access to formula, mother's health status (e.g. HIV status) and the frequency of breastfeeding in the mother's family and community.

Variables. Unqualified incidence, prevalence, morbidity, mortality and life expectancy, while useful, may be insufficiently informative – though the context of the study and consequent availability and utility of particular data will shape the selection of study variables. Combinations of measures or indicators in diverse thematic categories may be required to capture the broader concept of physical, mental and social functioning. For example, Disability Adjusted Life Years (DALYs) and measures of quality of life may better describe effects on health and wellbeing than other, simpler measures. Although many research projects will directly assess health outcomes, the investigation of well-established proximal determinants of health and wellbeing may also be relevant. However, when proxy variables of health are used, the link between the proxy variables and health must be clearly established.

This research programme is not designed to cover biologic determinants that are not somehow connected to other determinants. For example, the influence of the built environment on the infectious disease environment (prevalence of mosquito breeding pools, for example) would be of interest, as would the impact on immune function of fatigue and stress associated with long commutes. Purely biomedical studies are not likely to be of interest unless they take into account social and/or environmental determinants of health.

While the programme encourages innovative approaches to exploring complex environmental determinants of health, this should not dissuade researchers from including core traditional environmental concerns like water quality, air pollution, and exposure to noxious substances. Global environmental change, and the basket of issues associated with climate change, may be a core concern. There are well-accepted standards available for many of these variables, including nutrition and exercise, air and water quality and noise exposure. Appropriate adaptation and refinement/revision of these methods to the circumstances of the cities of the developing world (and the data available there) will be encouraged.

Feasibility. The data necessary to test the model under study must be available or obtainable, or studies must explicitly address the issue of data sparseness and quality. Any necessary agreements for data access or data collection should be described. In some cases, especially in developing world cities, data collection to fill critical research gaps may be necessary; projects should specify how this will be accomplished and where data will be housed on completion of the project.

End-users. As described under 'Process', projects should be designed in conjunction with relevant stakeholders; in many cases these will also be the primary end-users of forthcoming products. However, many projects will be expected to have implications beyond the immediate local environment and/or to generate tools, data and information that are of broader use. In so far as is possible, the complete range of end users should be identified at the outset and consulted where appropriate.

Products. In addition to scientifically sound research findings, study outcomes should include narratives and other materials directly relevant to the decision makers who have partnered with the research team as well as other relevant stakeholders. Other products may include the development of new shared data bases and the identification of research gaps and implications for future research.

5.2 Options for the thematic organization of the programme

A traditional ICSU science programme would normally be organized under scientific themes. This has the advantage of providing a structured framework under which projects can be solicited and organized. It can also help in communicating the main interests of the programme. However, a strict thematic framework can have the disadvantage of creating artificial distinctions or even barriers between different elements of a programme. This is particularly pertinent for the current programme which is specifically focused on using a systems analysis approach.

The Planning Group gave serious consideration to various options for thematic structuring of this programme. In particular two options were debated:

1) the use of themes based on groups of determinants (e.g. environmental) or health outcomes (e.g., chronic disease);

2) themes based on groups of problems (e.g. governance) or policy audiences (e.g. urban planners or health care providers).

It quickly became apparent that adoption of either of these approaches would be too restrictive and run a serious risk of undermining the over-arching 'ecological' systems approach of the programme. Defining projects in terms of specific themes could artificially limit the scope and nature of the variables to be included in projects and limit their usefulness.

It is proposed that the programme be initiated without specific scientific sub-themes. In this way projects would only be limited by adoption of the same broad conceptual framework (Fig. 3.1) and compliance with the general criteria described above (Section 5.1). As the programme develops over time, it may be possible to develop a more structured organizing framework that does not overly restrict the systems approach but encourages projects on important problems that are not being addressed. This is something that the Scientific Committee with oversight for the programme (see ahead, Section 7) will need to monitor and decide upon in due course.

5.3 Illustrative examples

Having decided against the adoption of specific scientific themes, the Planning Group decided to present a small number of illustrative ideas around which a systems analysis could be developed.

> *These examples have been put together specifically for this science plan by members of the Planning Group. They were chosen to illustrate the type of research that could be achieved by applying the defined criteria for the science programme and to suggest the nature of the teams that could be created. Hence, with some variability in presentation, these are examples of the programme's potential in a small number of selected areas.*

Urban transport, energy and health

The health impacts of urban transport systems depend on various factors, including transport modes, technology, transport policy, service level, land-use, and individual constraints about the possible choices of mobility. Positive health impacts arise from physical activity, access to education and employment, and social interaction; negative

health impacts result from air pollution, injury, noise and lack of physical activity, among others. Urban motorized transport is an important source of greenhouse gas emissions, which are changing Earth's climate and having additional feedback (mostly negative) impacts on health. Thus, the health impacts of time spent commuting in cities are now receiving attention from health researchers around the world.

In many cities, failure to consider the spectrum of health impacts from transport and land-use policies and investment has resulted in an urban environment that makes it difficult for people to get to jobs, health care facilities, education and services. In cities where the level of income in some segments of the population is rising, there is tension between the development of mass transport systems and ownership of private vehicles, which often symbolize economic and social status. This tension creates a negative feedback between the growing number of cars and the diminished need for, and investment in, public transport. Increased automobile use leads to increasing urban congestion, air pollution, sedentary living and obesity, and, in turn, to increased risk of diabetes, heart disease, chronic lung disease, stroke and some forms of cancer. The increase in greenhouse emissions leads indirectly to climate change which, in turn, may have multiple health consequences.

A systems analysis approach could improve understanding of the system-wide impacts of urban transport decisions and their consequences for health, at neighbourhood and city levels (see earlier Fig. 4.1). Agent-based methods would enable the examination of multiple consequences of human mobility, including scenario modelling of the energy system at both individual and community levels – by measuring the volume of greenhouse gas emissions from motor vehicles and the accumulation due to sedentary living of fat in the population.

The essence of urban policy decision-making is about trade-offs between economic, environment, health and social outcomes, including trade-offs between different health outcomes – e.g. safety *versus* physical activity. Sometimes it is easy, because there can be win–win opportunities for the environment, economy and human development. However, where it is not clear-cut (which is more often) quantitative systems analysis may be helpful. Decisions about urban transport investment will determine the "shape" of the city for generations to come. Quantitative systems analysis could enable examination of different scenarios and a range of transport/land-use interventions.

In summary, the health burden from urban transport systems persists despite the availability of sustainable transport technologies and international awareness of the health implications of unsustainable transport systems. Decision-makers persistently fail to consider holistically the health, social, environmental and economic impacts of urban transport and human mobility. Quantitative systems analysis may assist decision-makers in this terrain.

Table 5.2: Application of general criteria for urban transport and health	
Study element	**Requirements and description**
Scientific team	This project would need to bring together scientists and policy analysts from several disciplines including health sciences, environmental sciences, transport engineers and urban planning, and political economists.
Process	Transport planning and infrastructure decisions require political leadership and this project would benefit from collaboration with, and support from, civic and community leaders.
Method	This project would use the methods of systems analysis to define and describe relationships between multiple urban transport and land-use variables, and make predictions about health, social, environmental and economic outcomes.
Variables	Determinants of health include traffic injury rates, motor vehicle emissions travel times, and level of physical activity, and body weight, including mutual dependence and feedback interaction among all relevant factors.
Feasibility	Literature review and initial consultations indicate relevant data is available (excepting physical activity levels) in a number of potential urban settings. Procedures and/or agreements to obtain the data necessary to conduct the systems analysis would have to be secured.
End-users	The intention is to engage transport decision- and policy-makers across the project cycle – from framing study questions, identifying methodology options, through interpreting results, and communicating findings.
Products	This project will improve understanding of relationships between urban transport systems and health outcomes, and the findings will be pertinent to transport planning and infrastructure decision-making. The project will suggest new approaches to monitoring and evaluation in the transport sector.

The effect on health and wellbeing of urban vector-borne infectious disease

Infectious disease remains a serious threat to the health and wellbeing and social and economic welfare of urban dwellers worldwide. Among the most intractable of communicable illnesses to prevention and control efforts have been vector-borne – and particularly mosquito-borne – diseases. This is partly because of the potential for rapid amplification through infected vectors and partly due to the ongoing adaptation of vector and pathogen species to human control efforts and ecologies, but most importantly it reflects the long-underestimated complexity of vector-borne transmission systems. The failure of the WHO-sponsored Global Malaria Eradication Programme of the 1950s and 1960s and subsequent resurgence of malaria worldwide is but the most visible example of the consequences of approaching these problems with an insufficient understanding. Inherently complex, urban environments present special challenges for vector-borne disease control and prevention. Recent significant advances in epidemiology and control notwithstanding, gaps remain in our knowledge of diseases that are themselves highly responsive to the dynamic processes of global change.

The potential for serious urban health problems is greatest where vectors are particularly well-suited for urban transmission. *Aedes aegypti*, a mosquito species highly adapted to urban life, is primarily responsible for transmission of dengue and Chikungunya viruses, both of which pose risks to populations numbered in the billions, and for neither of which there is an effective vaccine. Even where vaccines are available, as for *Aedes*-transmitted yellow fever, low vaccination rates create the potential for serious urban outbreaks with significant loss of life. Although *Anopheles* mosquito vectors for malaria, the most serious global vector-borne disease – with up to half a billion cases and over a million deaths annually – are in general less-well adapted to urban life, there are exceptions (e.g. *A. stephensi* is a well-established vector for urban malaria in the Indian subcontinent), and urban cases are observed throughout endemic regions even where vectors are primarily rural.

There is evidence that many vector-borne diseases are expanding their ranges within and between major regions of the world, largely as a result of the growing interdependence of cities and regions, and associated increases in the movement of people and goods. Human-induced climate change may also be contributing to some of these ongoing changes in geographic range and seasonality. Moreover, in the case of malaria, there is constant attrition in chemotherapeutic and anti-vectorial efficacy with the development of resistance to successive drugs and pesticides.

In any particular city, vector-borne disease risk results from the complex interplay of many factors. The endemicity of the disease in surrounding rural areas and in cities linked by economic or social ties plays a key role, as do dynamic travel and residence patterns. Also important are factors that affect the ecology of vectors, including seasonality, breeding site availability and the built environment, factors that affect the response of individuals to disease challenges, including immunity and nutrition, and socio-economic factors that affect the use of prevention and treatment. Beyond the characteristics unique to urban areas are the spatio-temporal dynamics of the urbanization process itself. Urbanization is associated with shifts in the distribution of risk and immunity on a fine spatial scale. As cities grow, peripheral areas associated with high risk are absorbed; these geographic changes are typically accompanied by a shift in the relative importance of particular diseases (for example, increasing city size exerts a downward pressure on malaria prevalence, but increases risk of dengue). In some situations, the proportion at risk may decrease while population at risk increases. In the context of rapid global urbanization, a better understanding of urban management systems and the determinants of vector-borne disease transmission and morbidity in urban areas – structural, behavioural, environmental, economic, ecologic and epidemiologic – and of the complex relationships among them would significantly inform policymaking for urban health and wellbeing.

Cities, by nature, are focal points for intricately coordinated sets of inputs and outputs, goods, people, ideas, infections, policies and processes, all managed within densely concentrated yet highly heterogeneous spaces. In the specific case of mosquito-borne disease, significant ecological overlaps potentially allow for synergistic approaches to the control of various diseases (e.g. through integrated vector management); systems analysis is particularly suited to identifying and harnessing these synergies, and thus can pay high dividends in improved health and wellbeing. Moreover, as has been outlined above and elsewhere in this document, urban areas and populations are growing dramatically, especially in zones where vector-borne diseases are prevalent.

A systems analytic approach to urban vector-borne disease would be informed by data from an array of sources: economic, environmental/ecologic, infrastructural, behavioural/attitudinal, epidemiologic/health system and social/educational. It would incorporate sub-systems potentially ranging through compartmental models of transmission and vaccination, insecticide and anti-vectorial resistance, human and vector population forecasting models, climate and hydrology models, urban form and traffic-flow models, models of sanitation, urban water supply and urban drainage, social network mapping, models of economic decision-making, and models of rural-urban migration and travel choice. The most relevant research would identify the feedback loops, unintended effects and key decision-making points that most effectively inform policy for urban health and wellbeing, especially in the face of competing demands on urban management and health systems and limited resources.

This framework would address a wide diversity of policy questions in topics ranging from urban structural and transportation planning to distribution of health resources, effective public health education and communication, targeting of interventions, integrated control strategies for vector-borne disease, long-term stakeholder participation in disease surveillance and management, minimization of chemotherapeutic and insecticide resistance, and many others. A particularly important outcome of such research would be to reconcile the land use, urban and health planning perspectives, which frequently have only limited contact, in such a way as to improve urban health. Answering these complex questions will require a significant effort on the part of these communities—the techniques of systems analysis provide a solid foundation for this effort.

Table 5.3: Application of general criteria for urban vector-borne infectious disease	
Study element	**Requirements and description**
Scientific team	Multi-disciplinary teams of health, social/behavioural, environmental, and biological scientists are needed to avoid previous regional failures of malaria eradication, which suffered from an over-reliance on exclusive approaches.
Process	The scientific team would work with local decision makers since grass roots knowledge is essential for vector-borne disease control, including elimination of breeding sites, use of bed nets, or insecticide spraying of individual homes.
Method	A systems analytic approach to urban vector-borne disease would model interactions between an array of systems – from hydrology, transport, income and housing to classic epidemiological and parasitological systems and the policy and decision-making process itself – explicitly examining the effects of particular policies and interventions.
Variables	Well-defined health *outcomes* would include acute cases, hospitalizations and mortality. Potential *determinants* are diverse, and would include location of residence, proximity to mosquito breeding sites, extent of insecticide spraying, use of bed-netting in the home, access to treatment, and local patterns of chemotherapeutic resistance.
Feasibility	Demographic and health surveys provide an important resource, and local civic, business, or research initiatives often generate relevant social, behavioural or economic data. Modern tools, such as satellite imagery and GIS, can be supplemented by traditional field studies. One caveat that must be addressed is that the regions most at risk for these health issues often have the least – or least accurate – data.
End-users	Vector-borne diseases, particularly malaria, are the object of massive international initiatives (e.g. Roll Back Malaria). By forming strategic alliances with existing initiatives, it should be possible to build linkages with the international research community as well as relevant regional and local decision/policy makers.
Products	Findings from this project would help guide local decision-makers in health and urban planning and contribute important scientific knowledge for the international community concerned with urban vector-borne disease control and prevention.

Health, health finance and poverty

Research on this set of relationships was conducted by scientists at IIASA and Statistics Canada. They collaborated in development of a microsimulation model for the study of health and poverty in India. This is innovative in that the use of microsimulation in the context of the developing world is now mostly restricted to epidemiological models of diseases like malaria and HIV/AIDS. The model being developed, by contrast, consists of a set of core behavioural modules including basic family demographics, education, health status, labour market participation, income and savings. Implemented in the open-access Modgen programming language, it allows modellers with only moderate programming skills – comparable to those necessary for the use of statistical software packages – to refine and change models, or to add new modules. The approach is also innovative in that it is implementable at city scale. This research has considerable potential to contribute to decision-making by public health authorities, national fiscal authorities, and civil society.

Microsimulation is a powerful tool for the study of demographic change, providing insights into labour markets, household structure and income, taxes, social security, and a range of issues that broadly affect urban health and wellbeing. Models in this class simulate the individual life-courses of a sample of individuals representing a society, allowing for the possibility of interactions between individuals (marriage or divorce, for example, or infectious disease transmission), as well as spatial, social, and economic mobility. The sample size of the simulated population can be set such that simulation outputs are automatically scaled to a city or national scale. Strengths of the microsimulation approach are its ability to handle distributional issues both horizontally and longitudinally; to account for population heterogeneity; and to account for social support networks like families.

The ability to "pull out" individuals with selected characteristics (say urban women aged 20-29 in the 5th income decile in the base year) gives such models unparalleled ability to illustrate, for policy makers, the impact of their decisions on specific constituencies.

Health and disability, as well as recovery from sickness and disability, are modelled using piecewise constant hazard rates by age and sex. To date, the model only distinguishes two levels for each variable, i.e. being healthy or sick, and being disabled or not. Sickness and disability hazard rates rise with age; recovery rates fall.

Current research is focusing on refining the mathematical treatment of sickness and disability:

- The first step in this process is to distinguish the seriousness of sickness/disability and to prorate earnings accordingly. Disaggregating types of illness and disability, and estimating prevalence/incidence according to income decile is an obvious step in this direction.

- Foregone earning is only part of and, as international evidence shows, not the major impact of illness and disability on household income in poor countries. In India, only very few persons have health insurance and access to publically provided (or financed) health care is very low. For most Indians, then, health expenditures are out-of-pocket and serious medical events are a leading cause of poverty. The next step is therefore to estimate the direct cost of illness episodes (doctor visits, tests, drugs, etc.) by reference to survey data.

Simulations with this model will allow researchers to estimate the impact on household income and poverty, as well as on the life courses of selected individuals, of public provision or financing of health care as well as the cost to the public purse.

An example is the proportion of persons in each income group who must rely on indoor use of traditional cooking fuels, with consequent risks of respiratory disease that may be estimated from existing epidemiological studies and consequent health impacts. Another would be to compare the effectiveness of measures taken in areas such as water and sanitation or transport policy with measures designed to effect health directly. Through such work, the programme will encourage innovative scientific partnerships across disciplinary boundaries.

An increasingly important facet of applied modelling is convenient graphical user interfaces (GUIs) for model input (essentially, entering parameters and assumptions) and output (essentially, viewing results and producing tables and figure for reports). It is the user interface which supports easy navigation through parameter tables, manipulation of parameters, scenario settings, and scenario management. The ModGen language generates easily comprehensible and highly flexible GUIs for microsimulation modelling.

Water, food, health and wellbeing in cities

It goes without saying that water and food have a major influence on health and wellbeing. At the most fundamental level, they are essential for life, and, in light of this, the challenges in ensuring water and food security in urban areas are as critical as they are multi-faceted, complex and inter-related. At another level, food and water have central 'social' functions in almost all cultures and traditions and thus are major determinants of human behaviour. Food and water are also the objects of enormous commercial interest concentrated in urban areas with both positive and negative influences in terms of choices, diet and health.

The diverse choices and pathways taken by humans are rarely incorporated into contemporary engineering and science studies of urban water quality and resources. Water industries, water professionals and water utilities have historically focused on the infrastructure and technology that brings people their daily water and the complementary wastewater infrastructure, with a single-minded, "water-centric" focus on the recovery of water itself.At the same time, experts on food security tend to focus on food production, distribution, safety and quality, often ignoring (or separating) factors such as nutritional balance and individual choices. The Food and Agriculture Organization (FAO) defines food security as a "situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." (FAO, 2009). Food insecurity is a major problem for many urban populations and has substantial negative impacts on physical and mental health for adults and children. These effects occur both through direct impacts and indirectly, when harsh choices arise in the face of

Table 5.4: Application of general criteria for health finance and poverty in India	
Study element	**Requirements and description**
Scientific team	Collaboration between technical modelling specialists (Statistics Canada), development economists (IIASA) and Indian health economists/experts (IEG).
Process	The project involves intense collaboration of three stakeholders: include (1) public health authorities (focused on improving health outcomes), (2) fiscal authorities (focused on keeping public sector costs under control); and (3) the development community including civil society (focused on improving household wellbeing, especially among the poor).
Method	The model consists, in addition to accounting frameworks, of explicitly structured behavioural relationships and parameters, transparent and open to validation and debate. Researchers from a wide range of disciplines may wish to take advantage of the model as a basic driver of analysis in their sector of interest.
Variables	The model currently incorporates detailed demographic, economi and labour market data. Current work is deepening the treatment of health, relying on the National Family health Survey.
Feasibility	Whatever can be parameterized – whether through existing studies, special surveys, and econometric or statistical analysis of existing datasets, can be incorporated. Transparency and validation are, of course, key factors in establishing policy credibility.
End-users	Policy relevance is being assured through close partnership with a flagship national research institution that has good links with policy makers. Effective national partnerships increase the chances for far-reaching policy impact.
Products	Microsimulation modelling, with its ability to take population heterogeneity into account, to track individuals, and to consistently link micro-narratives with macro-consequences, is well suited to the telling of policy stories. User-friendly graphical interfaces for input and output make it well suited to producing materials needed by policy makers.

uncertainty about where one's next meal will come from. Interruptions in food supply have immediate impacts on human health, and when they occur on a major scale constitute public health emergencies. Within-population disparities in food security represent one of the most dramatic indicators of health disparities.

In a traditional research (and policy) approach, water and food experts would peer into the city from the detached, remote peripheries with little or no inter-communication, effectively ignoring the interdependence of their respective systems. An unconventional approach, in contrast, would make use of collaborative teams of such experts to ask how water and food infrastructures might be re-engineered to promote health and wellbeing within the city. Systems analysis is an invaluable tool in enabling the integration of previously unconnected perspectives. In the case of urban water and food, adopting such an approach is likely to lead to considerable gains in understanding.

The first step in this process is to reposition the sub-systems such that humans, rather than water and food production and distribution, now occupy the central position, the focus of attention. Such a reconfiguration, while seemingly trivial, raises an array of new and important questions about the kinds of infrastructures that are needed in urban areas, and sheds new light on old questions. This type of re-imagining is an essential part of the systems analysis approach. In this new conception, thinking, questioning and analysis now begin at the centre: with local and personal considerations of health and wellbeing; not out at the periphery, from the starting points of watershed hydrology or food production. It becomes clear that urban health is explicitly connected to a variety of elements of water and food infrastructural systems, and that they, in turn, are connected to one another.

Table 5.5: Application of general criteria to water and food project	
Study element	**Requirements and description**
Scientific team	Relevant disciplines with expertise in health sciences, hydrology and water engineering, and food security.
Process	The focus is an evolving collaborative communication between the scientific team and community leaders and decision-makers in which mutual goals are established.
Method	At the core of this research lies the use of systems analysis to test an integrated set of models for simulating the movement of water and food through the urban landscape in order to improve decision-making relevant to human health and wellbeing.
Variables	The project emphasizes a 'person-centric' approach. The individual's perception of what is important for his/her personal health and wellbeing – in respect of the many technical and social features of the urban water and food infrastructures – drives the choice of variables to be included in detail within the system's definition, hence the systems analysis.
Feasibility	Acquiring the data necessary for systems analysis is an essential challenge in this project. This is especially true of situations that will exist in the informal settlements and economies of cities, where data may be qualitative rather than quantitative in nature.
End-users	Stakeholders include neighbourhood associations, municipal authorities, the food industry, and state and national environmental regulatory agencies.
Products	The research findings should improve decision making to promote health and wellbeing through targeted re-engineering of water and food infrastructures and community education.

A systems analysis approach works with citizens, urban governments and utilities to illuminate the vital logical links amongst the private space of personal behaviour, the public space of city governance and the engineering and global implications of choices in those domains for sustainable cities.   Such an approach would draw upon the development and application of the following: (i) Multiple Sectoral Analysis of material and energy fluxes through the water, food, energy, and waste-handling economic sectors; (ii) simulation models of the urban water and nutrient infrastructures and the surrounding watershed/environment of the city; (iii) analysis of the "reachability" of wellbeing/sustainability goals under uncertainty; (iv) guidelines for Decision Making Under Uncertainty, under Ignorance, and under Contradictory Certainties; (v) technology foresight and assessment; (vi) development of Agent Based Models and their coupling to the urban water/food system simulation models; and (vii) psychological models of individual behaviour as a reflection of individuals' social bonds.

The principal aim is to identify those changes in policies that affect urban water and food systems that would most benefit health and wellbeing. At the same time, those forms of governance best suited to achieving these goals rapidly and practically must also be identified. Such analyses must consider the extent to which proposed solutions require changes in personal lifestyle, and how these changes themselves may represent impacts on human wellbeing. Indeed, the latter is a shifting target. For the very poor, wellbeing may have more to do with survival, whereas for the relatively wealthy, ideas of personal freedom and lifestyle may play a defining role. It is clear not only that some segment of governance must take this balancing act into account, but also that systems analysis is an appropriate tool for informing such a task.

6. The Science Programme

This chapter integrates and builds on key features of previous chapters that speak to the vision, timing, and approach of the Science Programme. Organization and funding are addressed in the next chapter.

Overall vision and approach

The overall vision for the Science Programme is to generate policy-relevant knowledge that will improve health status, reduce health inequalities and enhance the wellbeing of populations living in urban environments – environments that are, in any case, undergoing continual significant change, and which can be further modulated (if not transformed) by well-informed decisions taken in the interests of optimizing cities as health-supporting human habitats.

Scientists will work with decision-makers within a quantitative systems analysis framework to produce new scientific knowledge that will significantly contribute to these improvements. The programme has a temporal horizon of 10 years, during which the approach will be promoted, tested and validated in terms of shorter-term measures of health and wellbeing. An overall indicator of the success of the programme will be the extent to which this approach becomes anchored in research and urban decision-making over this period, with longer-term impacts on health and wellbeing being apparent on a 20-50-year timescale.

The proposed Science Programme is designed to build on synergies, focus on population health, prevention and promotion, add value to existing research in diverse domains, and hence address a critically important but as-yet inadequately studied perspective on the 'ecological' determinants of human health and disease. A critical feature is the designation of policy and decision-makers as participants in the development of research studies as well as recipients of research outcomes. The systems analysis approach offers a useful prospect for addressing the complex relationships between urbanisation and health that make informed decision-making such a challenge for policy-makers. In particular, this approach offers a scientifically grounded platform on which policy makers can base their decisions. Through the identification of gaps in current knowledge the programme might also be expected to influence national research agendas.

It would be simplistic to believe that better and more pertinent science alone will improve urban health and wellbeing. This report repeatedly acknowledges that urban governance will be the context in which the ultimate decisions will be made. This includes those who make decisions at the national and regional levels. There will inevitably be vested interests resistant to change and meritorious competing interests for often scarce resources. While the best science plan cannot in itself resolve these dilemmas, it can provide a credible basis for mobilizing the political will to make difficult decisions that will move governance structures increasingly closer to achieving health for all whom they govern. The extent to which decision-makers have a stake in and actively contribute to the programme increases the probability that they will make use of the results. The scientific community must also learn to work with decision-makers. The dialogue inherent to such a process will prompt adaptations and accommodations by both scientific and decision-making communities.

Programme structure

The four components of the proposed 10-year science programme are: research projects; methodology development; capacity building; and communication.

1. Promoting and coordinating research projects

The criteria for research projects that would fit within this programme are described in detail in Chapter 5 and Table 5.1 and illustrated by the preceding series of case studies. A systems analysis approach is a generic criterion for project selection. The general criteria require that projects (i) be inter-disciplinary, (ii) be collaborative, (iii) link urban health and wellbeing with multiple determinants of health, (iv) actively involve decision-makers, and (v)

provide outcomes that are usable by governance and other decision-makers. Unless the research is specifically addressed to remedying deficiencies in data availability and linkage, projects will also have to demonstrate that needed data are available.

The proposed Science Programme will encompass research conducted in different urban areas by different groups around the world. Each study will be different in terms of the variables of interest, but they will share the same conceptual framework (see Section 3) and commitment to a systems analysis approach (see Section 4). Some studies may be designed to allow direct comparison of urban environments in different settings/areas; others may focus on a single city, comparing local areas or observing changes over time. However, there should be enough commonality in either methods or core research questions to permit extrapolation as well as to facilitate integration and synthesis across studies and across regions.

The main objectives for the portfolio of research projects are:

1. To generate high-impact scholarly outputs;

2. To enable better-informed decision-making by the variety of stakeholders involved in urban-health and wellbeing;

3. To thus establish a systems analysis approach to health and well-being in the urban environment as a thriving and relevant area of interdisciplinary research.

2. Developing methodologies and identifying data needs

An important component of this programme will be the development of new systems analysis methodologies. Systems analysis will also evolve as a function of the requirements of the programme.

Among areas for further development is better integration of qualitative and quantitative information. Of particular importance to addressing determinants of health in urban settings is both access to information on health disparities and contextual information about the social, physical and institutional environment in which health is embedded. This includes formal and informal knowledge used to make decisions that affect health. Without these sources, it will not be possible to prioritize actions, nor to draw conclusions about resulting changes (positive or negative).

The identification and collection of data on the many aspects of the urban environment that influence human health and wellbeing are major challenges. As noted earlier, there are important limitations in data availability, quality and linkage. The complexity and diversity of urban environments and urbanization outstrip the current availability of data for implementing a comprehensive systems approach to urban health. Therefore, the programme will include research that addresses gaps in data quantity and quality. Meanwhile, the availability of appropriate measures and indicators of health and wellbeing cannot be taken for granted in many urban settings.

A number of initiatives are underway to promote more systematic collection and provision of essential data on cities and health. At the international level these include global monitoring activities, such as GEOSS (see Box 4.3). At the national level these include social surveys. At the city and regional levels, there are various initiatives to develop urban health observatories. Data from academic research, including GIS data, can provide an important complement to operational monitoring data. The GEO-Unions initiative (Box 4.2) is an excellent example of the importance of cataloguing existing models and data.

The main objectives of this programme with regards to methodology and data are:

1. To develop innovative systems analysis methodologies and approaches that are applicable to the particular challenges of health in the urban environment;

2. To identify data needs that inform and influence the various ongoing and planned observation and monitoring initiatives;

3. To reveal and/or generate new data from research studies that will be made fully and openly available.

Links will need to be established with the new ICSU World Data System that is being developed to ensure the long-term availability and stewardship of data for research and education purposes.

3. Building and strengthening capacity

A cross-cutting theme for the programme is building and strengthening capacity – both within the scientific community and among the programme's policy and decision-making partners. Indeed, enhancing capacity is central to achieving the programme's vision. Individual projects will provide an excellent training ground for students and early career scientists as well as for other stakeholders with an interest in project outcomes.

The research community currently involved in the type of interdisciplinary research described in this programme is fairly small. International collaboration has a critical role to play in expanding this community. ICSU and IIASA have established strong track records in strengthening capacity, most notably in the area of global environmental change research. ICSU has recently established Regional Offices, which could play an important role in promoting the programme and facilitating networking and project development in lesser developed countries.

IIASA has productive partnerships with academic institutions across the world. Capacity-building is integral to the mission and values of both organizations. These are strong foundations on which to build the capacity-building work of the health and wellbeing programme.

The main objectives in relation to capacity-building are:

1. To build the scientific capacity and interdisciplinary platforms necessary for undertaking research into urban health and wellbeing using a system analysis approach;

2. To build the capacity of policy makers and practitioners to absorb to scientific research into urban health and wellbeing using a system analysis approach;

3. To expand the number of young scientists with capacity to undertake research into urban health and wellbeing using a system analysis approach that engages with substantive policy relevant issues.

4. Communicating new knowledge: promotion and outreach

An important added value of the programme and a rationale for using a common conceptual framework is to permit the integration of knowledge from different projects. This will lead to the generation of new (and more fundamental) insights into causal pathways and hence to the testing of new scientific hypotheses. It will also generate a consistent and comprehensive evidence base on which sound policy decisions for improving urban health and reducing health inequalities can be developed.

Integrating the scientific knowledge generated by the new interdisciplinary programme and making it available to decision makers and other stakeholders in a way that is readily understood will be another major challenge for the programme. The Planning Group recommends that the remit to the first Scientific Committee include a priority on the development of a comprehensive communications strategy addressed to scientists, decision-makers and other stakeholders. Although local partners are critical to individual projects, a communications strategy broadly inclusive of all collaborating partners will be a vital component for developing a new shared culture of inquiry and informed decision-making.

The development of a coherent international science programme, in contrast to a collection of highly variable projects, has the advantage of enabling centralized promotion and advocacy of the programme. Key target audiences are the scientific community, the policy community, civil society, and funding bodies. Each of them includes many different players, who will need tailored communications for different purposes. For example, the communications strategy should include an outreach component incorporating activities such as an interactive web-site that will serve both knowledge transfer and development of research capacity through on-line seminars.

Maximum use should be made of existing international organizations, networks and fora that have an interest in urban health. Strategic partnerships should be developed with key bodies (see Annex 2), and with new interdisciplinary networks and fora established as necessary to complement those that already exist.

The main objectives with regard to communicating new knowledge are:

1. To use web and internet technologies to create a virtual forum that will become a point of reference for both the scientific community and other stakeholders;

2. To promote interaction and collaboration between researchers and with other relevant stakeholders, via conferences and workshops;

3. To make results available to multiple stakeholders in a relevant format that allows them to be easily understood.

7. Organization and funding

The proposed organization and funding for the suggested programme is based on the flexible model that ICSU has tried and tested over many years. This model has proven to be successful for the coordination of different areas of international research and most notably in relation to global environmental change. The essential elements are a scientific committee, an International Programme Office with necessary resources and good links to the ICSU Membership, relevant partners and the wider scientific community.

Scientific Committee

The future development and implementation of the programme will be overseen by a Scientific Committee. This will be made up of a representative group of international scientific experts from different geographic regions and reflect the interdisciplinary nature of the programme itself; hence the behavioural, medical, natural and social sciences should all be represented.

International Programme Office (IPO)

As for other ICSU programmes, it is proposed that an International Programme Office (IPO) be established and act as the 'motor' for the programme, under the oversight of the Scientific Committee. The IPO will have its own dedicated director and necessary scientific and administrative support staff. It should be located in an academic institute (or equivalent) that has urban health as one of its main priorities and is committed to an interdisciplinary approach to this topic. 'In house' expertise in systems analysis methodologies or close institutional links that will facilitate access to such expertise would also be advantageous. The planning group identified the need for strategic input from the policy community and the mechanisms to ensure this will need to be given due attention.

Funding

Funding for the IPO and its staff will be expected from the host country, with an initial commitment of five years. The Programme Director should also have a remit for securing additional funding for specific activities, e.g. training, workshops and publications.

Funding for individual projects will be secured by investigators from a range of funding sources. In its discussions, the Planning Group noted that health research is supported by multiple sources: national research councils, international funding agencies, philanthropic foundations (some linked to corporations), and in some cases decision-making government agencies or private firms themselves. Scientists are not expected to have difficulty identifying potential funding sources appropriate to their proposed projects. The greater challenge is that traditional health funders may not appreciate the urban dimension or the promise of systems analysis, and considerable effort will be required at the programme level to advocate for the relevance and potential impact of the work proposed.

Advocacy and promotion of the programme with funding agencies will be an immediate priority for the Scientific Committee and IPO. The aim should be to have the theme widely adopted as a strategic priority, with recognition being given to project applications that fit with the programme criteria.

Links with ICSU's Scientific Unions, National Members and Interdisciplinary Bodies

The scientific community as represented by the ICSU membership will, of course, be essential to the implementation of the programme. It is encouraging that many of the Unions have been working together for several years in an initiative on health and wellbeing[1] The Unions have a dual role both in promoting the programme via their established communication channels and in supporting project development and

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[1] During the 2002 ICSU General Assembly, 12 ICSU Unions met and identified a trans-union initiative on Science for Health and Well Being (SHWB). The initiative has been maintained with the goal of promoting specific research programmes by marshalling expertise that transcends scientific boundaries into coordinated programmes designed to attain new insights into research and policies that affect the health and wellbeing of people.

participation by scientists from the various disciplines. The initiative of the Geo-Unions to develop a catalogue of existing models and data sources applicable to the urban environment (see Box 4.2) is a good example of how the Unions can contribute to the programme. It must, however, be recognized at the outset that some key actors, for example urban planners, are not within ICSU's traditional ambit.

National members can contribute to the programme in various ways, depending on their own structure and resources. At one end of the spectrum, those members that have responsibility for the distribution of research funding can actively support the programme by including it in their scientific priorities. At the other end, the dissemination of programme information to national research and policy communities is also important.

Several of ICSUs established interdisciplinary bodies, most notably the global change programmes, already have an active interest in issues relating to urban health (see Annex 2). These bodies have a key role to play in ensuring that their activities are coordinated with the proposed new programme.

It is proposed that the Steering Committee and IPO organize periodic 'open forums' to promote the engagement of interested ICSU Members and Interdisciplinary Bodies in the programme.

ICSU Regional Offices

The ICSU Regional Offices for Africa, Asia and the Pacific, and Latin America and the Caribbean have a potentially important role to play in promoting the programme, particularly in the less developed countries. In 2007, the Regional Office for Africa carried out a broad review of health research needs in the region that identified urbanisation as a particular challenge. At the time of writing, the Regional Office for Asia and the Pacific was about to initiate its own planning exercise on urban health, with the aim of integrating this into the overall ICSU programme.

The Regional Offices can play a critical role in identifying local scientific expertise and working with the IPO to convene meetings and workshops with multiple stakeholders to develop project proposals. Establishing and maintaining regional research and knowledge networks should represent a major aspect of the capacity-building component of the overall programme.

Links with IIASA

Through its Health and Global Change Project and others, IIASA has been engaged in systems modelling of health and poverty, urban malaria, and health effects of indoor and outdoor air pollution. To capitalize on this expertise and support research under the Science Plan, IIASA is exploring the establishment of a unit on systems modelling of urban health to serve as a technical secretariat to the programme. Specific potential activities include providing technical assistance both for proposal development and for accepted proposals and the convening of an annual modelling forum where researchers can share expertise, results and lessons learned.

Partners and/or co-sponsors

Implementation of the programme and adoption of its outcomes will be dependent on the establishment of effective strategic partnerships and good communication channels with a variety of organizations and networks. A number of these potential partners are listed at Annex 2. These include relevant UN and intergovernmental organizations, such as WHO and UN HABITAT, as well as stakeholder networks that variously involve civil-society actors, industry and academia.

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Annex 1: Terms of reference and membership of the ICSU Planning Group on Health and Wellbeing in the Changing Urban Environment[1]

Terms of Reference

Taking into account the report of the CSPR ad-hoc Scoping Group on Human Health – Towards a Systems Analysis Approach to Health and Wellbeing in the changing Urban Environment, and the workshop jointly organized by ICSU, IIASA and the International Scientific Unions on this topic (Vienna, 24-25 January 2008), to:

1. consult with the relevant stakeholders (WHO, city policy-makers, business and NGOs) and define the key health policy questions to be addressed in relation to the changing urban environment;

2. define in detail the short, medium and long-term goals and deliverables for a new interdisciplinary programme in this area;

3. develop an inventory of existing (sub-system/sectoral) models applicable to the urban environment;

4. develop an overall systems analysis model framework that incorporates 1, 2 and 3 and also takes into account the interactions between key external drivers and sectoral factors (see report of the ad hoc Scoping Group);

5. define the data and information sources necessary to carry out an informative systems analysis using this framework;

6. identify a small number of cities in which this model could be tested and refined;

7. define the structures and identify possible funding sources that would be necessary to ensure the initial implementation of the programme in the identified cities;

8. develop a mechanism that, during both the planning itself and subsequent programme implementation, ensures the full involvement of all interested ICSU constituents (Unions, National Members, IBs and Regional Offices);

9. provide an interim progress report to the ICSU General Assembly in October 2008[2].

Planning Group meetings

The Group met on six occasions between January 2008 and May 2010. The first of these meetings was held at IIASA (Laxenburg, Austria) immediately following a workshop that was co-organized with the ICSU Unions. Four of the five other meetings were held at the ICSU Secretariat in Paris and the other one in Beijing, China. Meeting Four in Paris and Meeting Five in Beijing were each combined with discussions with local academics and urban policy makers. A brief summary of these two meetings is given below

Meeting 4 (Paris)

The Planning Group visited St Denis, a deprived urban area of Paris. A discussion forum was held with the Deputy Mayor and several of her colleagues involved in developing and implementing policy for different urban sectors, e.g. public health and housing. This was followed by presentations and discussions with the "Délégation Interministerielle à la Ville" – an inter-ministerial task-force established to develop an integrated approach to improve urban deprived areas. The presentations included a new initiative to develop an urban health observatory.

Meeting 5 (Beijing and Sanshui)

With the generous support and assistance of the ICSU Member in China, CAST, a half-day meeting was held in Beijing with representatives of various key institutions involved in monitoring and advising on public health policies at both the national and city level. The planning group then undertook a two-day visit to the city of Sanshui, which is rapidly becoming a centre for high-tech development and production with substantial multinational involvement. Sanshui is also renowned for the longevity of its inhabitants and has the largest population percentage of centenarians of any Chinese city. The Planning Group was fortunate to participate in the First International Conference on Environment Development and Health and Longevity, which brought together a large number of city mayors, urban planners and managers from different regions across China. This provided a unique opportunity gain insights into the issues and questions that are of most concern to these key Chinese urban decision-makers.

[1] Approved at the 14th meeting of the ICSU Committee on Scientific Planning and Review, September, 2007
[2] The interim report was accepted by the 29th General Assembly, which decided "to request the Executive Board to continue to support this planning exercise and, after full consultation with Members, to consider the implementation of a new initiative"

Planning Group Membership

*Françoise Barten *(Co-chair)*
Nijmegen Urban Health Group
Radboud University
6500 HB Nijmegen
The Netherlands

Bruce Beck
Warnell School of Forest Resources
University of Georgia
D W Brooks Drive, Athens,
Georgia 30602-2152, USA

Suzanne Bennett Johnson
Department of Medical Humanities
and Social Sciences
Florida State University College of Medicine
Tallahasee Fl 32306-4300, USA

Anthony Capon
National Centre for
Epidemiology & Population
Australian National University
Canberra ACT 0200, Australia

Osman Galal
International Health Program
Dept of Community Health Sciences
UCLA School of Public Health
Los Angeles, CA 90095, USA

Edgar Gutiérrez-Espeleta
Escuela de Estadistica
Universidad de Costa Rica
Costa Rica 2060

Dov Jaron
School of Biomedical Engineering
Science and Health Systems
Drexel University
32nd and Chestnut Streets
Philadelphia, PA 19104, USA

*Landis MacKellar *(Co-Chair)*
International Institute for
Applied Systems Analysis
Schlossplatz 1
A-2361 Laxenburg, Austria

Elijah Ogola
Department of Clinical Medicine & Therapeutics
University of Nairobi
P.O. Box 19676 00202
Nairobi, Kenya

Susan Parnell
Department of Environmental and Geographical
Sciences & African Centre for Cities
University of Cape Town
Private bag 3, Rondebosch, 7700
Cape Town, South Africa

Pierre Ritchie
School of Psychology
University of Ottawa
Ottawa, ON K1N 6N5, Canada

Gérard Salem
Faculté des Lettres et Sciences Humaines
Département de Géographie & IRD
Université Paris Ouest
92001 Nanterre Cedex, France

Wuyi Wang
Institute of Geographic Sciences and Natural
Resources Research,
Chinese Academy of Sciences
11A Datun Road, Beijing 100101, China

José Siri *(ex officio)*
International Institute for Applied Systems Analysis
Schlossplatz 1
A-2361 Laxenburg, Austria

Carthage Smith *(ex officio)*
International Council for Science

*Francoise Barten and Landis MacKellar were
appointed as co-chairs for the Planning Group
after the first meeting, which was chaired by the
ICSU Vice-President for Scientific Planning and
Review, Khotso Mokhele.

Annex 2: Selection of international initiatives relating to urban health

ICSU initiatives

1. *Earth Systems Science Partnership (ESSP):* urbanization and health is one of several themes is the GEC-Health programme that was launched in 2007. The major focus of the programme is environmental change and its impact on health

2. *International Human Dimensions Programme (IHDP):* launched a core project on Urbanization and Global Environmental Change in 2005. Focuses, from a social sciences perspective, on the roles of environmental change as both driver and product of urbanisation

3. *Scientific Committee on Problems of the Environment (SCOPE):* organized, together with UNESCO, a meeting on "Urban futures and human and ecosystem wellbeing" in October 2010, as part of a proposed new initiative on emerging urban system management.

4. *Regional Office for Africa:* has developed a broad science plan for health in Africa, with urban health being identified as a particular priority.

5. *Regional Office for Asia and the Pacific:* is establishing a planning group on urban health to help implement the current programme in the region.

IIASA initiatives

1. Microsimulation modelling of health and poverty in India by IIASA's Health and Global Change Project (HGC), in collaboration with the Institute for Economic Growth in Delhi. This initiative covers both original research and capacity building components.

2. A similar initiative is being explored with the Institute for Population Studies at Peking University.

3. Research on air pollution and health in Asia, carried out under IIASA's Atmospheric Pollution and Economic Development Program (APD).

4. Research on links between education, health and economic growth by IIASA's World Population Program (WPP).

5. Research on links between indoor air pollution and health and access to clean fuel in India, being carried out under IIASA's Energy Program (ENE).

6. Research on the systemic relationships between vector-borne disease transmission and urban processes, under the supervision of IIASA's HGC Project.

UN and intergovernmental

1. WHO Commission on Social Determinants of Health (CSDH): responding to increasing concern about persisting and widening health inequities health inequities – the unfair and avoidable differences in health status seen within and between countries – WHO established the Commission in 2005 to provide advice on how to reduce them. (paraphrased from http://www.who.int/social_determinants/en/)

2. WHO Centre for Health Development Kobe, Japan: "the Centre promotes the acquisition of knowledge and its application to the improvement of health in development... [w]ithin the overall purpose of reducing health inequity in urban settings." (from http://www.who.int/nmh/about/kobe_centre/en/)

3. WHO, Healthy Cities (http://www.euro.who.int/Healthy-cities)

4. WHO–UN HABITAT (http://www.unhabitat.org/)

5. UNEP Geocities: the GEO-Cities (http://www.grid.unep.ch/activities/assessment/geo/geo_cities.php) initiative started in 2000 in response to calls by UNEP's Governing Council and Global Ministerial Environment Forum (GC/GMEF), the Initiative for Sustainable Development in the Latin America and Caribbean region (LAC), the LAC Forum of Ministers (WSSD), and the Millennium Development Goals (Goal 7 on Environmental Sustainability). One of the main objectives is to establish a consensus on the most critical environmental problems in each city and to make it possible to formulate and implement urban strategies and plans to help cities improve urban environmental management.

6. UNEP Geo-Health : the GEO-Health (http://www.pnuma.org/deat1/geosalud.html) initiative is a methodological approach by UNEP and PAHO to undertake participatory integrated environmental and health assessment in Latin America and Caribbean, based on the UNEP GEO methodology and the WHO Health and Environment Analysis for Decision-making (HEADLAMP) initiative.

7. UNESCO MAB programme (http://portal.unesco.org/science/en/ev.php-URL_ID=6393&URL_DO=DO_TOPIC&URL_SECTION=201.html)

8. World Bank, Urban division (http://www.worldbank.org/urban/)

9. OECD, cities and regions (http://www.oecd.org)

10. IPCC (http://www.ipcc.ch/)

Stakeholder networks

1. Cities Alliance (http://www.citiesalliance.org/ca/)

2. International Society for Urban Health (http://www.isuh.org/)

3. International Water Association (http://www.iwahq.org/Home/): The International Water Association (IWA) is a global network of water professionals, spanning the continuum between research and practice and covering all aspects of the water cycle. In particular, IWA hosts some 50 technical groups, including one on Sustainability in the Water Sector, another on Systems Analysis and Integrated Assessment, and one on Health-related Water Microbiology. At many IWA events, fora are devoted to the interests of policy and decision makers, such as city mayors and corporate-sector leaders.

4. Global City Indicators (http://www.cityindicators.org/)

5. *International Council for Local Environmental Initiatives (ICLEI):* a network of representing more than 475 cities worldwide with an interest in sustainable development

6. *World Business Council on Sustainable Development:* a CEO-led, global association of some 200 companies dealing exclusively with business and sustainable development.

7. Resilience Alliance (http://www.resalliance.org/1.php)

8. Alliance for Healthy Cities (http://www.alliance-healthycities.com/)

ICSU
International Council for Science

Strengthening international science for the benefit of society

5, rue Auguste Vacquerie
75116 Paris, France

Tel: +33 1 45 25 03 29
Fax: +33 1 42 88 94 31
secretariat@icsu.org

www.icsu.org