

ENVIRONMENT AND HUMAN HEALTH

**Research on Complexity of Risk from Environment-
related Diseases**

Research Framework

ZEF Round Table on Health

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ABSTRACT

Increasing population, geological factors, rapid urbanisation, agricultural developments, global markets, industrial development and poor resource management have affected the quantity and the quality of environmental resources. These activities have not only exhausted the existing resources, but also have triggered its contamination by naturally occurring toxic minerals (fluoride, nitrate and arsenic), and chemical pollution from rapid industrialisation affecting human health and their environment. The environment is intricately linked with a number of sub-systems of urbanisation, agricultural activity, food security, and human health, making it a complex system responding to stimuli in various sub-systems. Complexity, non-linearity and interactions across multiple scales are compounded by the interplay of social, political and technological processes.

ZEF's research aims at examining the risk from the influence of the complex global environmental change on human health. This is examined using a sequential combination of comprehensive and integrated perspectives. Taking a comprehensive perspective helps to understand the openness of the system and the diversity of actors and components that interact within the system, while an integrative perspective helps in understanding the interaction of the key components that exhibits self-organisation capacity, making the system a complex adaptive system. This sequential combination helps to design rules, and build capacity of human entities to facilitate the designing of rules to manage risk posed by global environmental change on human health. This is vital for prevention of diseases, for human well-being, and, more importantly, for alleviation of poverty.

The presented framework identifies three phases for managing risk. The first phase assesses the health risks and the vulnerability of different social groups to environment-related diseases (i.e. the respective health risk impacts). The second phase aims to develop sound health risk strategies, based on a multitude of biophysical and socio-economic clues. The third phase examines the existing risk adaptation measures to reduce or eliminate risk through diverse management strategies. Understanding the integrated nature of risk from environment-related diseases requires adopting a combination of disciplinary, interdisciplinary and transdisciplinary approaches to environment and health research. The research seeks to make substantial and innovative contributions in the field of global change and human health research.

Keywords: water pollution, human health, complexity, risk management, risk assessment, adaption, mitigation

1. INTRODUCTION

Sustainable use of environmental resources has come under increasing stress in recent decades. Most basic needs and livelihood activities depend on the availability of fresh water, good quality land and air. Increasing population, geological factors, rapid urbanisation, agricultural developments, global markets, industrial development and poor resource regulation have affected the quantity and the quality of environmental resources. With its availability becoming scarce, meeting the basic needs and supporting livelihood requirements for human well-being and for alleviation of poverty becomes a challenge. This scenario is further complicated by the rapid evolution of pathogens and viruses as they interact with society and their environment. The evolutionary ‘trial and error’ approach of pathogens not only defeats the most carefully thought out human defence strategies, but also gives rise to new human pathogens. This is known as zoonosis: non-human viruses cross the species barrier (Woolhouse, 2002). The emergence and re-emergence of pathogens illustrates the intimate intertwining of disease dynamics with socio-political, economic, ecological and demographic change (Bloom et al., 2007). This confronts contemporary stable institutions and standard health interventions. Complexity, non-linearity and interactions across multiple scales are compounded by the interplay of social, political and technological process. Understanding the complex ways in which local and global forces influences risk on human health and their environment is a challenge. ZEF research on environment and health focuses on understanding the complexity of risk for prevention of diseases, for human well-being, and, more importantly, for alleviation of poverty.

ZEF’s research on environment and health aims at designing policies and strategies to develop efficient public health care schemes to improve human health for sustainable development (ZEF, 2007:20). It has three objectives:

- i. Understand the linkage between global environmental change and public health;
- ii. Build the capacity of the public sector institutions to address the growing challenge from global environmental change;
- iii. Build capacity as a centre of excellence for public health research;
- iv. Build capacity of regional institutions in public health research to advocate policy change in their respective countries.

ZEF research will focus on the entire population ranging from local neighbourhood to as big as an entire country, where it attempts to protect and improve health through a comprehensive approach - this in contrast to clinical professionals primarily treating individuals after they become sick or injured. This 'public health' perspective will help to improve the health and well-being of people in local communities and across nations, with special focus on vulnerable and marginal sections of the population. (<http://www.whatispublichealth.org/what/index.html> accessed 15 Sep 2007).

2. UNDERSTANDING THE ENVIRONMENTAL HEALTH -- A Conceptual Framework

Environmental health has emerged as a major public health concern as a result of global environmental changes. Environmental health can be defined as the excessive presence of chemical, physical or biological substances (pollutants) in water, land and air due to human activities with a harmful effect on human and their environment. The global environmental change includes changes in the physical and biogeochemical environment, either caused naturally or influenced by human activities that are globally integrated or occurring by worldwide aggregation (Leemans et al., 2009:1; Confalonery & McMichael, 2007:8). These developments are a multi-layered process, questioning the existence of a linear relationship between environmental pollutants and its human impact. McMichael sums up this point by emphasising (in his conversation with Shetty, 2006:21) that most of the contemporary attempts at controlling environmental related health problems are "attuned to simple high-school models of science, with clear-cut cause-effect relationships, most of us are yet to grasp the risks to human societies and health from these escalating changes to the world's complex non-linear systems, whether climate system or ecosystems". Environmental health is intricately linked with a number of sub-systems of urbanisation, agricultural activity, food security, and human health, making it a complex system responding to stimuli in various sub-systems (McMicheal, 2001: Label, 2003).

There are two basic interpretations for unravelling the systems perspective. The first takes a *comprehensive* perspective that a broad array of variables and their interrelationships should

be examined (this draws on Emory Roe (1998) and the collection of papers in *Ecology and Society*, volume 4, number 2). The second takes an *integrative* perspective by suggesting that the complexity of living systems of people and nature emerges, not from a random association of a large number of interacting factors, but rather from a smaller number of controlling processes (Holling, 2001). These processes establish a persistent template upon which a host of other variables exercise their influence. Such ‘subsidiary’ variables or factors can be interesting, relevant, and important, but they exist at the whim of the critical controlling factors or variables (Holling, 2001). These ‘comprehensive’ and ‘integrated’ perspectives do not represent alternative views, but may be thought to represent a sequential combination: comprehensive assessment helps to understand the openness of the system and the diversity of actors and components that interact within the system, while an integrative assessment helps in understanding how the interaction of the key components that exhibits self-organisation capacity, making the system a complex adaptive system (Railsback, 2001; Mitchell, 2005).

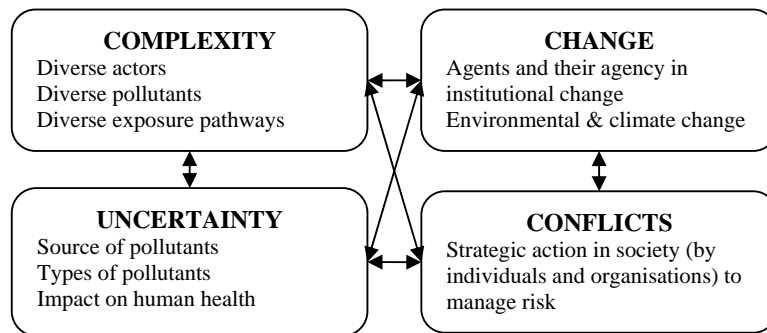


Figure 1. Environment and Health in a Complex Adaptive System

The complex adaptive system consists of four inter-related properties characterising its structure dynamics – complexity, uncertainty, conflicts and change (Mitchell, 1997) (see Figure 1). The diverse actors degrading the environment affect human health through multiple pathways, making for ontological complexity of the system. This interacts with demographic, socio-cultural, economic, and other regional factors that have differential impact on human individuals and their environment, and which are not completely understood. Often this results in considerable uncertainty in which decisions have to be taken. With incomplete and imperfect understanding, human entities (individuals and

organisations) develop strategic action, often resulting in competing claims and demands over the environment. These conflicts are facilitated (or constrained) by socially or institutionally distinct agents, who attempt to change (policies and programmes) the existing institutional arrangements and bio-physical environment (through technology or other means). These changes are not always perfect or efficient, but the system has the capacity to self-organise.

The fact that we live in a society of complex adaptive systems means we live in a ‘risk society’ (Beck, 1992). The concept of ‘risk society’ does not want to imply that the world is more hazardous than linear, as closed system perspectives suggest. Rather, it recognises a “modern approach to foresee and control the future consequences of human actions” (Giddens, 1999:3-4) by adapting to risks rather than assuming they can be eliminated or fully controlled. The aim of ZEF’s research is to understand the risk posed by environment-related diseases on human health and the environment. This will help in managing risk to sustain livelihoods of the deprived sections of the population, in the context of growing urbanisation, industrialisation and increasing population.

3. PHASES OF MULTIFACETED RISK MANAGEMENT

The World Health Report (2002) argues that focusing on risks to health is the key to prevention, as much of the scientific effort and most health resources today are directed towards treating disease. With roots in environmental risk assessment, research on health risk has gained prominence in recent decades to comprehensively understand the ability of a society to take risk in a responsible way. Risk management aims to purposefully design rules, and at the same time build capacity of human entities to self-adapt rules to manage risk from environment-related diseases in order to sustain the livelihood of people, in the context of growing challenges from global environmental change. This requires a comprehensive understanding of risk from environmental pollutants on human health by identifying the pathways of risk and vulnerability assessment, analysing the diverse set of strategies adopted by human entities and the changes brought about by human entities in the existing institutions

and bio-physical resources. The research framework identifies three phases of risk governance research¹ (see Figure 2).

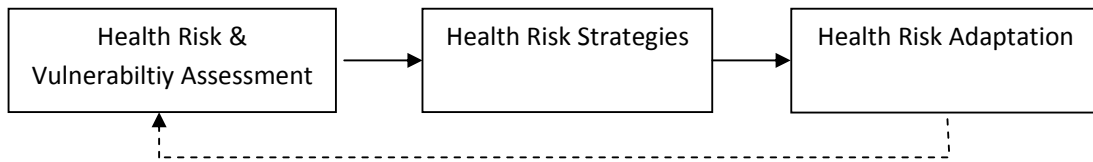


Figure 2. Phases of Risk Management Research

The first phase assesses the health risks and the vulnerability of different social groups to environmental (mis)management (i.e. the respective health risk impacts). The second phase aims to develop sound health risk strategies, based on a multitude of biophysical and socio-economic clues developed by human entities. Phase three examines the existing risk adaptation measures to reduce or eliminate risk through diverse management strategies. Understanding the integrated nature of risk from environmental (mis)management on human health, and risks from environment-related diseases on socio-economic, institutional and environment requires adopting a combination of disciplinary, interdisciplinary and transdisciplinary approaches to environmental-health research. ZEF’s research will adopt diverse research methods depending on the context and apply different modelling approaches (for example GIS-based and Bayesian network approaches) to gain a better understanding of the risks from environment-related diseases.

3.1 Health Risk and Vulnerability Assessment – Complexity of Pathways

The analysis of risk assessment involves documenting of material exposure of environmental pollutants and analysing the vulnerability of individuals and organisation. The health risk assessment examines the prevalence and exposure pathways that individuals and society face

¹ In recent years, the International Risk Governance Council (IRGC, 2005; 2007) has developed a risk governance framework drawing from the sociological perspective for understanding of risk (see Renn, 2008 for details).

in the event of environmental pollutants (air, water and land). It investigates the diverse set of factors that exposes these individuals and society to these pollutants resulting in various environment-related diseases. The vulnerability assessment examines both the awareness of the individuals and societies to the risk posed from pollutants, and their ability to cope with/manage these risks.

Understanding exposure is a key element in the ability of a society to assess the risk posed by environmental pollutants. Exposure is defined as “the contact at one or more boundaries (e.g. mouth and skin) between human and a contaminant(s) at a specific concentration(s) for a period of time (Lioy, 1990). The exposure pathway starts from the release of pollutants into the environment, to a concentration of the pollutants in one or more environmental media, to actual human exposure, to internal or delivered dose, and ultimately to environmentally induced disease and injury (Sexton, et al., 1992. Exposure has four aspects:

- (1) Route – do exposures occur by inhalation, ingestion, dermal contacts and injection or a combination of these?
- (2) Magnitude – What is the pollutant concentration (e.g., parts per million, micrograms per cubic meter, milligrams per litre)?
- (3) Duration- what is the duration of exposures- minutes, hours, days, and lifetimes?
- (4) Frequency – how often do exposures occur – daily, weekly, monthly or seasonal?

Briggs (2003) argues that there is no single source of pollutants causing exposure to health effects; we are exposed to multiple mixes of pollutants, often derived from different sources, some of which may have additive or synergistic effects. Further, these forms of exposures are related to human behaviour, and social, cultural, demographic and economic factors. The myriad ways in which these factors influence and interact with environmental conditions, exposures, human susceptibility and health outcome, questions the effect of environment *per se*. It is this combination of material risk and the socio-cultural dimensions that contribute to risk assessment. Sexton et al. (1992) conceptualise a series of events (Figure 3) that helps our understanding on the material risk associated with environmental pollution. Evaluating the health risks associated with pollutants is composed of two primary activities: (1) exposure assessment, and (2) effects assessment.

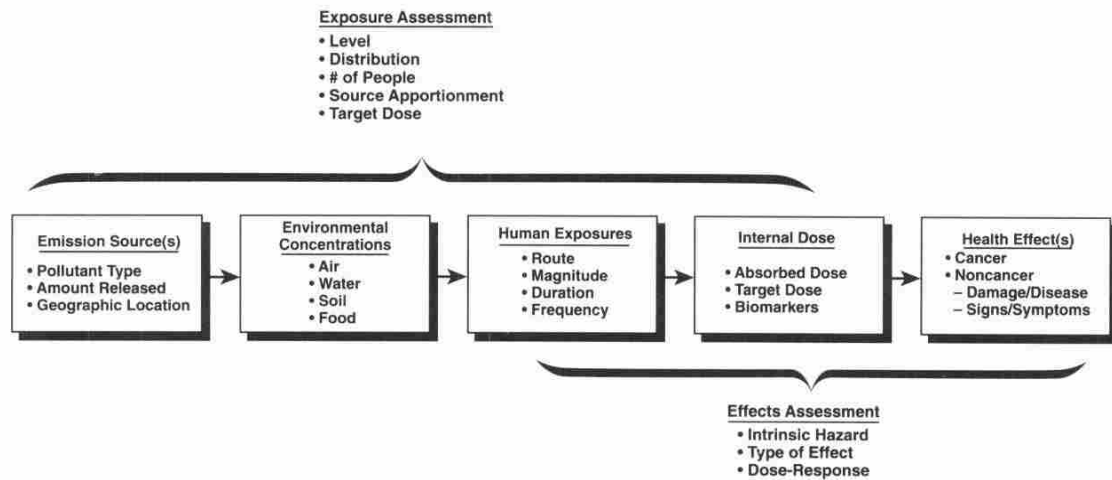


Figure 3. Relationship of Exposure Assessment and Effects Assessment to the Environmental Health Paradigm

Source: Sexton et al., 1992:399

Exposure assessment evaluates the initial portion of the event chain, while the health effects assessment focuses on the final portion of the even sequence, i.e., exposure, dose and adverse effects. The goals of the latter evaluation will be twofold: a) determine the intrinsic health hazards associated with the pollutant; and b) quantification of the relationship between exposure and health effects in human populations. Understanding or establishing the link between pollution sources, human exposures and adverse health effects will provide insights for establishing governance arrangements to protect against harmful consequences of pollution (Sexton et al., 1992). The conceptual framework of emission source to possible health effects informs the passage of pollutants towards health impacts, and offers a framework to map the effect of human behaviours, and social, cultural, demographic and economic factors that influence risk perception.

Pathways of social perception are based on the exposure to the events and the ability of the society (individual and groups of individual) to amplify or attenuate a risk. It is not a simplistic process. Kasperson et al. (1988) argue in their social amplification of risk framework (SARF) that it is a dynamic process. In this process certain hazards and events that experts assess as relatively low in risk can be amplified, while others that experts judge

as most serious get less attention from society (it is attenuated). The amplification of risk occurs at two stages: a) in the transfer of information about the risk, and b) in the response mechanisms of the society. Amplification denotes the phenomenon by which information processes, institutional structures, social group behaviour, and individual responses shape the social experiences of risk, thereby contributing to risk consequences. The interaction reveals that the information systems and characteristics of public response that compose social amplification are essential elements in determining the nature and magnitude of risk. The starting point of the social amplification of risk framework (SARF) is that 'risk events' which might include actual or hypothesized accidents and incidents will be largely irrelevant or localized in their impacts unless human beings observe and communicate them to others. The key part of this communication holds that risk and risk events and the characteristics of both become portrayed through various risk signals (images, signs, and symbols). These risk signals interact with individual and social amplification stations, which in turn affect institutional and social behaviour, creating ripple effects in the society and its subsequent impacts (Kasperson et al., 2003). The framework demonstrates the importance of the social construct to acquire or create interpretations of risks.

This SARF framework has a number of areas that require improvement in order to make it relevant for public policy. First, the framework represent a simplistic one-way transfer of information – from risk events, and sources, through transmitters and then on to receivers. Pidgeon et al. (1992) argue that social risk perception is an interactive process. Second, Breakwell and Barnett (2003) observe that social amplification and attenuation processes are complex dynamic social phenomena. They suggest a 'layering' method as an integrative and multidimensional technique for collecting data and identifying relevant relationships. Third, the framework has focused more on the views of individuals, rather than on organisations that are responsible for managing risk, and on the larger societal context. Fourth, the framework is suitable for general analysis rather than specific analysis of particular events. Fifth, the framework does not itself address many of the process underlying the risk communication. Sixth, risk is not only a result of the social constructs, but also is a material construct, and it is the interaction between these that constitutes risk. Finally, the framework could be amended to offer insight in understanding the process behind individual and societal amplification (and attenuation) of risk. Social perceptions are intertwined combinations of the attitudes of

individuals (socio-cultural and economic factors) and behaviour of the existing institutions (media, public and private organisations). Understanding these complex sets of factors will offer insights on the role of existing governance arrangements and social and cultural factors in shaping perception of risk posed by environment-related diseases.

Different exposures and risk perceptions contribute to differential impact on human health (individually and communally, over space and time), giving rise to multiple vulnerable groups. The complexity of exposures and assessments contributes to a situation in which decisions have to be taken in the face of considerable uncertainty due to incomplete and imperfect understanding of the impact. Assessing the impacts requires placing health at the centre-stage to identify risks for different sections of the society that are measurable, risks that we know but are not measurable, risks that we are ignorant about, and risks that we cannot determine. Health impact assessment (HIA) has emerged as a discipline developing decision-support tools to predict the future consequences of implementing different activities and policies on health (Kemmer, 2005). The most widely quoted definition of HIA is “a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population” (EHP, 1999:4). This approach primarily views health impact as a result of the causal influence of policies, programmes or projects, but rarely reflects McMichael’s (2001) ‘health as an integrated index’.

Health is an integrated index of social, physical, institutional and political factors. Human health is not only an individual entity influenced by biological functioning of the human body, the presence of genes, humans’ nutritional status, and their life history, but also is a collective property of a population (McMichael, 2001), where the circumstances, experiences and dynamics of the groups and populations play an equally important role. In addition to this individual and collective property aspect, human health is also influenced by the evolution of pathogens, which increases the resistance capacity of infectious diseases leading to their emergence and re-emergence. This makes the linkage between environment and human health a complex and contingent process (Briggs, 2003). The complex linkage between environment and human health is highly interdependent, non-linear, and context specific. This calls for a more complex and dynamic perspective on human-disease-

ecological systems, in contrast to the simplistic linear pathways of impact assessments. However, this offers two major challenges for the public research community. First, they need to go beyond their professional boundaries and paradigms, and second, move beyond examining local and global to a more integrated global-local interface (McMichael, 2006). Assessing the impact of environmental pollution on human entities and their environment will help in identifying measurable risks, uncertain risks (that we know will affect humans but are uncertain), risks that we are ignorant about and, risks that we cannot determine at all. This will help in influencing medical and institutional decisions in the face of considerable uncertainty, as it is not realistic to wait until analysts develop the depth of understanding that we would like to have before committing ourselves to a path of action.

3.2 Health Risk Strategies

The environment-related disease leads to human entities to develop differential strategic actions. These actions range from seeking medical advice to home-remedies, from street protests to conflicts among different social groups (upstream versus downstream, agriculturists versus industrialist). These strategic actions have a rationality of their own and are short-lived. Analyzing them is important to understand the causes or factors behind these actions. How do individuals and society perceive uncertainties from environment-related diseases to develop strategies? How do risk-related cognitions and emotions influence uncertainties, and what roles do socio-demographic and contextual factors, risk judgement and information exposures play in this differential action and why?

Griffin et al. (1999) developed the risk information seeking and processing (RISP) model. The model integrates the heuristic-systematic processing model and the theory of planned behaviour to examine how people differentially react to risk information. The RISP model postulates that the gap between what people know and what they perceive they need to know (information sufficiency) will influence information processing (i.e., heuristic or systematic) and information seeking (i.e., active, routine, avoidance) behaviours. In turn, information sufficiency is predicted by affective responses to a risk and beliefs about what others think they should know about the risk. Bennett (1999) reveals that trust, freight factors, values, risk comparisons and understanding the probability of risks have an important bearing on

actions. Langford et al. (1999) draw on cultural theory to analyse strategic actions depending on understanding of the health risk. Though these models offer explanatory power, they have a limited use to structure or restructure existing institutions and their functions to govern risk.

3.3 Health Risk Adaptation

The strategic action of individuals and society are carried and promoted by socially or institutionally distinct agents (Strydom, 2008) to adapt or change the inadequacy of existing resources and institutional arrangements. These agents, who mutually recognise the risk, embody different perception and management strategies in accordance with distinct modes of engagement with the world. These agents make sense of and act upon a risk in multi-levelled network in and through which incoming information about a given risk reality is processed in a socially distributed way (Strydom, 2008). Occupying different positions yet parallel to one another, each of the participating agents frames and communicates the mutually recognised risk in their own way to adapt or to bring about necessary changes. Thereby agents activate resonance structures which allow responses in the form of feedback of one kind or another as well as connections to be forged. In doing so, each of them contribute to the way in which the risk becomes collectively classified, understood and dealt with.

Social theorist like Giddens and Archer have provided significant insights towards understanding the agents and their constituency around their emergence. Agents for Giddens (1984:xxii) are individuals, who have as “an inherent aspect of what they do, the capacity to understand what they do while they do it”. They possess ‘transformative capacity’ (1984:15), which is another way of saying they possess power. The transformative capacity emerges as a result of routinization, a basic element of day-to-day social activity and fundamental concept of structuration theory, where structural properties (rules and resources) are constantly recreated out of these resources (Giddens, 1984:xxiii). Archer (2003:118) recognises agents as individuals, but argues that there are “*collectivities* sharing the *same life-chances*’ (emphasis as in original). Giddens (1984) recognises the role of structures, as agents are born within them and inherit their agency from them (Archer, 2000:262, cited in

Llewellyn, 2007). These agents ‘are people with a project’ (Sayer, 1992:119; Archer, 2003:2-3, cited in Llewellyn, 2007:134), pursuing a common good. Prospects to understand the adaptive management of risks in practice, requires examining agents and their agency. Facilitating the adaptive management practice of agents if combined with the institutional analysis approach of Ostrom (1990) will help in identifying institutions and their differential role in facilitating (or constraining) change for a sustainable future.

Examining risk in a comprehensive manner, as health risk and vulnerability assessment, health risk strategies and health risk adaptation will offer insights for comprehensive intervention strategies. Assessing health risk and vulnerability will examine past practices, global and local actors, and socio-ecological changes that have influenced environmental pollutants. The impacts of environmental pollutants on human health depend on the diverse socio-economic, institutional and ecological factors prevailing at the particular period. Giving rise to different vulnerable social groups, and diverse uncertainties that humans have to adapt or change. Analysing risk strategies will enhance interventions to build capacity of organisations and individuals in overcoming health impacts. Adaptation to risk will enhance interventions to facilitate (or constrain) change for a sustainable future of public health. Overall this will enhance the capacity of public agencies to design rules and build capacity of actors to adapt and integrate rules for governing risk for sustainable public health. Some of the key issues and themes for research on public health that are useful to advance further are given in Table 1.

Table 1. Themes for research

RESEARCH PHASE	RESEARCH ISSUES	RESEARCH THEMES
HEALTH RISK & VULNERABILITY ASSESSMENT	<p><i>Material Risk</i></p> <ul style="list-style-type: none"> • Source of pollutants (activities) • Causes of pollutants (social institutional and ecological) • Process involved in its contamination, and their inter-linkages. • Forms of exposures (human and environmental) <p><i>Social Risk</i></p> <ul style="list-style-type: none"> • Factors driving different forms of exposures. • Factors contributing to different risk perceptions 	<ul style="list-style-type: none"> • BIOMES AND HUMAN ACTIVITIES • EXPOSURE MAPPING • RISK PERCEPTION ANALYSIS • PROBLEM ANALYSIS • EPIDEMIOLOGY OF HUMAN HEALTH • HEALTH IMPACT ANALYSIS

	<p>and their inter-linkages</p> <ul style="list-style-type: none"> • Impact of exposures on human health. • Differential impact of pollutants on human and environment. • Policies and programmes contributing to these differences. • Socio-cultural, demographic and Institutional factors facilitating (or constraining) the impact.. 	
HEALTH RISK STRATEGIES	<ul style="list-style-type: none"> • Existence of different strategies to address pollution. <ul style="list-style-type: none"> • Organisational strategies • Technical strategies • Socio-cultural strategies • Legislation, economics and socio-cultural factors facilitating strategies. 	<ul style="list-style-type: none"> • CAPABILITY ANALYSIS
HEALTH RISK ADAPTATION	<p>Agents and Agency involved in adaptive management. Socio-economic, cultural and Institutional factors facilitating or constraining them.</p>	<ul style="list-style-type: none"> • ADAPTIVE CAPACITY • AGENCY

Gaining knowledge on the different phases will enhance the capacity to govern risk posed from environment-related diseases, to alleviate poverty and at the same time to add to effective resource management. This should offer insights for necessary changes in the prevailing governance arrangements for the modern state to be effective in delivering development and security (Fritz and Menocal, 2007:532). In specific, it will offer insights to enhance the developmental role of the state for consciously designing rules, and at the same time, building capacity of organisations to design rules to manage risk. This embraces the state as a network of authoritative institutions that makes and enforces top-level decisions throughout a territorially defined political entity (Chesterman et al, 2005).

4. PLAN FOR A ENVIRONMENTAL HEALTH RESEARCH PROGRAMME

ZEF's research on environment and health proposes to comprehensively investigate the risks from environment-related diseases on human health in five broad research areas.

1. *Adaptive Responses to Water-borne and Vector-borne diseases*: The research calls for developing adaptive responses through epidemiological studies to understand the relationship between human behaviour and health outcomes, applying GIS-based risk mapping and Multi Agent Modelling to project water-borne and vector-borne diseases, institutional analysis and means to facilitate adaptive response.

2. *Urbanisation, Agriculture and Human Health - Examining the Complexity of Linkages:* Rapid urbanization and wastewater irrigation in peri-urban societies has placed many of the urban and peri-urban communities at risk, especially in fast-growing economies. The research will examine the interlinkages among these diverse sets of factors to: gain insights for sound legal and regulatory frameworks, offer thorough understanding of the factors that drive farmers to (re)use wastewater, growing domestic waste and rapid population growth for effective public health protection and maintenance of environmental quality.
3. *Globalisation and Human Health:* Industries, especially small-scale industries are emerging as one of the major consumers of water resources and in recent years, fertile land, combined with poor urban and regional planning to dispose of large quantities of chemically polluted wastes. The research will analyse the global forces and their interaction with local and regional factors impacting on human health, which is central for the development of adaptive management strategies for industrial pollution.
4. *Adaptive Responses to Geogenic Pollution:* Excess fluoride, arsenic and nitrate in drinking water and water used for domestic purpose have caused serious public health problems in South Asia, Latin America, and Africa. There are a number of contradictory accounts on the origin, exposure to and the socio-cultural and institutional impact dimension. Research should be directed towards understanding the contamination route to water sources, different forms of exposures on humans and towards developing adaptive responses from the existing institutional arrangements.
5. *Global Environmental Change and Human Health:* One of the most evident and adverse effects of global environmental change has been the development of waterlogging and salinity on agricultural land of the Indo-Gangetic Plains (India-Bangladesh). The research will examine the linkages between human and natural causes of land degradation and the impact of saline drinking water sources on human health.

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