RESEARCH PROGRAMME (Joint Environment & Human Health) FINAL PROGRAMME REPORT

Programme Duration: 2006-2010
Co-funders: NERC, EA, Defra, MOD, MRC, The Wellcome Trust, ESRC, BBSRC, EPSRC and HPA

Strategic Objectives , theme challenges and programme objectives and extent of achievement

The Joint Environment and Human Health (E&HH) programme was formulated to address the interface between the natural environment and human health, in the context of the overarching question of **'How do we effectively manage the natural environment to improve human health?'**

In this context, this primarily **capacity building** programme explored how both man-made and natural changes to the environment can influence human health. Scientists have tackled the complicated mix of environmental, social and economic factors that influence health, particularly focusing on naturally occurring toxins, man-made pollutants, nanoparticles and pathogens to see:--

- how they spread within the environment
- how their properties change as they interact with other substances or organisms
- how we become exposed to them, and
- their impact on human health.

A multidisciplinary research approach would clearly be needed, which in turn required collaboration across a range of funding organisations. E&HH ultimately brought together nine different funders, including UK Research Councils (the Natural Environment Research Council, Economic and Social Research Council, Medical Research Council, Biotechnology and Biological Sciences Research Council and the Engineering and Physical Sciences Research Council), Government Departments (DEFRA, Environment Agency, Ministry of Defence) and a charity (The Wellcome Trust).

In its first phase, the principal objectives of the Environment and Human Health programme have been to (i) identify and prioritise the research needs within the four broad areas identified above and (ii) encourage, grow, develop and facilitate the research community required to tackle the "real-world", inter- and multi-disciplinary problems faced not only in the UK but globally. Therefore, E&HH has aimed to:

- create a constituency for both inter- and multi-disciplinary work that would underpin our understanding of the links between the environment and human health
- provide better knowledge that would improve our ability to identify and predict emerging issues of potential concern
- improve the evidence base for risk assessment and regulation of activities needed by government departments and agencies, and other stakeholders

with the aim of improving the health of people, both in the UK and globally.

Themes & Approaches

Identifying and prioritising the research needs was a principle objective for E&HH in

its first phase. Using information collected during the various consultations, the E&HH Science Advisory Committee identified a number of potential areas of interest, and these are summarised below.

Transport and dynamics of micro-organisms of human health importance in the natural environment

- response of microbial transfers to environmental change
- science based issues of scaling up from the local site to the catchment or appropriate policy level
- gene flow (e.g. involving antibiotic resistance) through the microbial horizontal gene pool
- harnessing a systems biology approach to help understand complex processes in the soil microbial environment where indirect impacts on human health may result in terms of surface water quality or bathing water quality
- interactions of microorganisms and pollutants
- integration and quantification of risks to humans through both environmental and other pathways
- the risks of organic agriculture (including trans-national transport of pathogens) through different approaches to crop and animal production

Emerging infectious diseases

- risk assessment, the use of indicators, and anticipatory modelling of novel pathogen dynamics
- influence of global and local environmental change (e.g. climate change, nitrogen deposition, deforestation; as well as land use change, for example CAP reform and the EU Water Framework Directive)
- ecology of wildlife reservoirs and vectors in emergent diseases
- role of farm workers in disease transmission

Transport and dynamics of both chemicals and particles of different sizes and compositions in the natural environment that are of human health importance

- assessment of exposure and bioavailability from various physical (soil, water, air, food) and behavioural pathways through different routes (e.g. developing and using effective biomarkers) to better inform toxicology, epidemiology and human risk assessment
- active features of particles that cause problems, e.g. surface properties, size and composition
- interactive effects of mixtures of chemicals in the environment and the impact on human health, exploiting sensitive analytical and molecular techniques
- chronic low level exposures to toxins, leading to human health effects including trans-generational toxicity (genetic and epigenetic) and other long term outcomes
- inter-individual susceptibility to environmental factors and interactions (e.g. toxicity), including genetic make up, particularly with respect to susceptible groups such as foetus, children, elderly, and those with ill health or receiving medication; including the extent to which these differences may be socially structured
- effect of changes in the environment (e.g. climate change, land use change) on human health; regulatory changes leading to land use change and impacts of changes on the pollution profile and nutrient depletion
- soil degradation and trace metal deficiencies affecting human health

Technologies providing new capabilities for establishing and predicting the impact of the environment on human health

- application of new techniques including computational, physical, engineering, analytical chemistry/biochemistry methods, i.e. application of massively parallel screening approaches possibly using new lab-on-a-chip methods for understanding the interplay of pathogens/toxic agents with other environmental agents on human health.
- novel techniques for studying pathogenic microbes or pollutants (chemicals or particles) in the environment where a potential link to human health may be important.
- approaches to enable an understanding of the impact of nanotechnology and nanoparticles on human health.
- data analysis/modelling tools, including approaches such as machine learning or other intelligent agents, possibly providing predictive capability from large data sets gathered from social, environmental or medical studies. It is anticipated that these tools could provide predictive models of relevance to human health, or alternatively provide models for fate and transport.

Social, economic and behavioural factors in the genesis and health impact of environmental hazards

- what are the macro-social factors and processes for example, business organisation, trade, urbanisation and population change, influencing the exposure of people to environmental risks and hazards (pathogens and pollutants)?
- what is the role of factors such as socio-economic status, age, gender, and culture in shaping behaviours relevant to environmental health risks?
- how does a stressful social or physical environment impact on biological processes linking the environment and disease?
- what is the importance of age, culture, social position, disability, and illness for resilience and adaptive capacity in the face of environmental health hazards?
- what is the impact of differing perceptions of risk and attitudes in enhancing public engagement and dialogue about environment and health issues?
- how are political, economic, cultural and social forces shaping the emergence of new environmental health risks and benefits and how may these be managed?
- can we quantify the benefits to human health of changes in the environment such as the spatial distribution of and access to green space?
- what are the economic and social costs (or benefits) of environmental impacts on health?

Building a New Community

In order to successfully tackle the research priorities identified above, collaborations among scientists that had traditionally not worked closely together needed to be facilitated. Consequently, the focus of the E&HH Programme has been on **capacity building** and supporting inter-disciplinary activities such as:

- proof of concept studies or exploratory awards;
- workshops/networks;
- working groups
- "discipline hopping" opportunities to encourage career development for young scientists.

Extent of Achievement

The Joint Environment and Human Health (E&HH) Programme has successfully contributed to the capability building, while also generating new science in the four areas defined above.

The Programme has not only succeeded in bringing together scientists from a broad range of environmental, social and biomedical backgrounds, but also fostered new relationships with end users and policy makers. This new community is helping to provide the multidisciplinary capacity able to respond in an interdisciplinary way to resolve problems that are intrinsically interfacial in character. Many of these questions relate to complex issues such as the environmental biology and geochemistry of soils and how these influence the transport, accessibility and bioavailability of chemical pollutants and infectivity of pathogens. The dispersion of harmful particles in the atmosphere is another area of major concern where the E&HH Programme has broken new ground by showing how the chemical and physical properties of such particles influence their environmental behaviour and may govern their toxicity and resultant pathological reactions induced following inhalation. Working groups and networks have identified potential health problems concerning the transport and emergence of human pathogens associated with food, soil, air and water. The consequence(s) of global and regional climate change for the environmental behaviours of pollutants and pathogens have been considered by a number of the projects supported by the E&HH programme.

By effectively identifying and interconnecting these interdisciplinary elements, the E&HH programme has fostered the emergence of new ways of solving problems in areas of research that have, until recently, had little connection with one another. This has not only helped build new research groupings, but has also led to exciting new scientific developments.

A summary of activities and key outputs *e.g. actions undertaken to achieve the scheme/programme objectives. Outputs are reported in detail in ROD, but it would be helpful to have some aggregate narrative/selection of highlights for NERC to use in its reports to government.*

The Joint Environment and Human Health (E&HH) Programme has explored how both man-made and natural changes to the environment can influence human health. Scientists have tackled the complicated mix of environmental, social and economic factors that influence health, particularly focusing on naturally occurring toxins, man-made pollutants, nanoparticles and pathogens as indicated in the previous section.

The Joint Environment and Human Health (E&HH) programme was formulated to address the above areas, in the context of the overarching question of **'How do we effectively manage the natural environment to improve human health?** Summary findings from the 37 projects are described in ANNEX 2, and publications arising from the 2009 Annual Science Conference, which were published in a special issue of *Environmental Health*, are included in ANNEX 7.

The £4.4m E&HH programme supported 37 projects that covered a broad range of environmental concerns linked to human health. They addressed a complicated mix of environmental, social and economic factors that influence health, particularly focusing on naturally occurring toxins, man-made pollutants, nanoparticles and pathogens to ascertain:

- how they spread within the environment
- how their properties change as they interact with other substances or organisms
- how humans become exposed to them, and
- their impact on human health.

There were also projects investigating the effects of micronutrient deficiencies in agricultural soil on maternal and post-natal health in Malawi, the potential beneficial effects of an association with nature and human well-being (biophilia), and plant virus infection as a determinant of pollen allerginicity.

The perturbation of environmental interactions as a consequence of global climate change is an important sub-theme running through many of the E&HH supported projects on pollutants, particles and pathogens.

Collectively, these projects have brought together scientists from many disciplines including environmental and social science, medical, biomedical and public health research. The various projects have also interacted closely with government departments and agencies. Sharing such diverse knowledge and skills has enabled an improved holistic view on how the environment influences human health, and identified key areas for further investigation.

A summary of Outcomes (achievements) *measured against the objectives outlined in the Programme's Science, Data Management, Knowledge Exchange, Communications Plans, International Collaboration*

Some specific achievements arising from the interfacial research that characterise the E&HH programme are presented below, and these underline why the problems being addressed by this programme, can only be addressed by multi- and interdisciplinary groups of scientists working together in cohesive collaborative projects:

Food & Environment

1. A survey of recent and ongoing research indicates that the health benefits of organic foods may be over-rated, although further investigation is essential before making critical comparisons with normal foods. There appears to be little or no evidence at present to suggest that there are any quantifiable effects on human health from consuming organic rather than conventional food, and the environment in which food is produced has a far greater impact on the nutritional and contaminant composition of the food than the system in which the food is produced. This project dealt with a complicated set of potentially interacting factors including soil science, pesticide toxicology, biogenic fungal toxins and infectious pathogens, as well as the nutritional composition of the foods in question.

Chemical Pollutants

2. Development of a robust analytical system that can be used for the assessment of the bioaccessibility of arsenic and polycyclic aromatic

hydrocarbons (PAHs) in a simulated human gut environment. This has resulted in the development of a patentable test kit. The experimental model of the human digestive tract has provided a novel way of testing the behaviour of harmful toxic environmental contaminants is influenced by the complex interactions between the gut chemistry and microbiology. This project has also demonstrated the detrimental impact of PAHs on the microbial flora from the human gut.

Particles & Nanoparticles

3. Evidence obtained that the fluids in the lung can modify the biological reactivity and pathogenesis of airborne nanoparticles causing aggregation of inhaled ultrafine particles thus modifying their biological behaviour and reactivity in the lungs. In combination with lung epithelial cell exposure studies, evidence has been obtained for an adsorption mediated damage mechanism. This may be important for both atmospheric particulate material and synthetic nanoparticle exposure via the lung and possible subsequent translocation to the circulatory sysytem, and such data will help in predicting hazard and risk associated with synthetic NP exposures.

4. In lung tissue dosed with real samples of urban air particulates there is a differential in gene and protein response dependent upon the size fraction used. Notably there was significantly more down-regulation of proteins and genes than up-regulation and this increased at smaller particle size. This is the first time that the gene and protein responses of size fractionated (in the nanoparticle range) real environmental air samples have been tested on human lung tissue.

5. Silver nanoparticles are known for their antibacterial properties (exploited in wound dressings), but the impact of their release into the environment has been largely unknown. The findings have demonstrated the toxicity of silver nanoparticles in a human food-chain model including invertebrates, fish and mammals.

6. Impurities in carbon nanotubes may contribute to toxicity, however, these occur at scales that are invisible to the techniques used in their characterisation by manufacturers.

7. No characteristic physico-chemical structural signature that might be useful in pre-screening for potential toxicity of all nanoparticles. A number of individual characteristics that can cause toxicity including:

    - positive zeta potential
    - high content of nickel and zinc
    - high aspect ratio (i.e., length : cross-section) in fibres and nanotubes

8. Oxidative potential of atmospheric nanoparticles is related to the size and chemical composition of the particles.

Biogenic Toxins

9. Inhalation of endotoxin at elevated concentrations has been associated with acute airway obstruction, hypersensitivity pneumonitis, chronic bronchitis and decreased lung function. Although waste management activities are acknowledged as a source of environmental endotoxins, causing occupational exposure, little information regarding endotoxin dispersal from green waste composting, and the potential for non-occupational exposure, has been available. The findings have demonstrated that bacterial endotoxin associated with airborne particles produced by commercial composting have detrimental biological effects on an *in vitro* cell-based model of the lung. Demonstration that bacterial endotoxin is associated with airborne particles produced by commercial composting, which have detrimental biological effects on an in vitro cell-based model of the lung. This project underlines the problem of how coatings of biological origin may affect the harmful biological reactivity of micro- and nano-scale particles.

Climate Change, Chemical Pollutants & Pathogens

10. Climate change is likely to increase human exposures to agricultural contaminants. The magnitude of the increases will be highly dependent on the contaminant type. Risks of many pathogens, particulate and particle-associated contaminants could increase significantly. However, the research suggests that these increases in exposure can, for the most part, be managed through targeted research and policy changes.

Pathogens

11. Information on environmental contamination with viruses, or their potential for persistence in the environment or in the food chain, is currently incomplete. A Report has been submitted to NERC, Defra and HPA on the environmental pathways for exposure to pathogenic viruses and emerging viral problems (e.g., from farm animals and global transport of food products from industrial organic farms in China, Mexico and California). Identification of current knowledge gaps regarding transmission of viruses through the environment and food. This project brought together a wide range of medical and environmental virologists and microbiologists, food and public health scientists, and epidemiologists.

12. MRSA and other drug-resistant microbes are no longer just a problem in the hospital environment. They are present in the natural environment, with the attendant concerns about the transfer of the genes conferring drug-resistance to other species of bacteria. Research supported through the EHH programme has led to development of screening tests for MRSA in the agricultural environment. MRSA is no longer just a problem in the hospital environment. MRSA and other drug-resistant microbes are present in the natural environment with the attendant concerns about the transfer of the genes conferring drug-resistance to other species of bacteria. This project brought together microbial ecologists and clinical microbiologists in order to address the health risks posed by the widespread presence of MRSA in the environment, where it is associated with pig herds, bovine milk and faeces. Dairy products have also been implicated as reservoirs of MRSA in Europe.

13. Human disease causing bacteria can survive inside free-living helminth

worms (nematodes) and are protected from the action of chemical sanitiser treatment. Food-borne diseases are a significant public health problem where pathogens such as *Salmonella* occurring in the soil can interact with such organisms. The inference is that soil nematodes can provide a protective micro-environment for human pathogens with health implications for the persistence of such pathogens in the soil.

14. Evidence of space-time clustering amongst females for cases of type 1 diabetes diagnosed in north-east England, and clustering was confined to cases from more densely populated areas. These findings are consistent with a possible aetiological involvement of an infectious agent.

Epidemiolology & Health Risks

15. Substantial progress has been achieved towards deriving a summary measure of multiple environmental deprivation at small area level, akin to the measures of multiple socioeconomic deprivation used by health researchers from many disciplinary backgrounds. The key achievements have been to i) systematically identify which elements of physical environment should beincluded in the measure, ii) compile appropriate environmental data for the whole UK, iii) produce several different versions of the measure iv) discover independent associations between the measures and variation in all cause and cause specific mortality, and v) begin to examine the interaction between social and physical environments on health inequalities in the UK.

16. Global food insecurity is associated with micronutrient deficiencies and it has been suggested that 4.5 billion people world wide are affected by deficiencies in iron, vitamin A, iodine and zinc. The most vulnerable are young children and women of childbearing age. A pilot study is underway in Southern Malawi that attempts to link the geochemical and agricultural basis of micronutrient supply through spatial variability to maternal health and associated cultural and social aspects of nutrition. Data analysis is currently underway in the UK on soil and blood samples from a field study in Malawi on the effects of micronutrient depleted soils (e.g., selenium) on maternal health and postnatal development. This is undoubtedly the most logistically challenging project supported by the E&HH programme, involving soil geochemists, healthcare workers and biomedical scientists working together under very difficult social and cultural conditions in central Africa.

A summary of Impacts (longer term value delivered as a result of the Programme) *e.g.mechanisms for effective, long-term post programme exploitation of data, enhanced efficiency, enhanced uptake of science end-users, increased investments and opportunities including UK lead in the science area impacts on policy, private sector, public services and quality of life, UK economy. It is expected that many of the impacts will not yet have materialised as the programme has only just finished. It would be helpful for future economic impact studies if programme could identify areas of expected future impact. Would help to give examples of the types of impacts e.g. policy, private sector, public services, quality of life, UK economy*

A number of issues have arisen as a result of the Joint E&HH Programme and some of these have contributed to the development to the 2 successor programmes (**EEHI** & **ESEI**) described below.

The key issues are summarised as follows:

1. Quantifying the links between ecosystem degradation and adverse effects on human health

2. Chronic long-term exposure to low concentrations of harmful particles and chemicals

3. Health implications of exposure to mixtures of chemical pollutants

4. Nanotoxicology – relative toxicity and possible contributory role in degenerative diseases

5. Nanoparticles and protein misfolding in the etiology of neurodegenerative diseases

6. High aspect ratio nanomaterials (HARN) such as nanotubes and nanowires – possible risk of fibres acting like asbestos in cellular toxicity

7. Need to monitor workers in nanotechnology industries and users

8. Toxicity of mixtures of nanomaterials and bound conventional toxic chemicals (e.g., metals and polycyclic aromatic hydrocarbons and heterocyclic compounds

9. Global and regional implications of emerging zoonotic pathogens

10. Risks from food-borne microbial and viral pathogens

Successor programmes to Environment and Human Health

The UK Natural Environment Research Council (NERC), Medical Research Council (MRC), Economic and Social Research Council (ESRC) and Biotechnology and Biological Sciences Research Council (BBSRC) are supporting two new programmes of research that will tackle the major roles environmental and social factors play in human health.

The vision for these initiatives is the establishment of truly interdisciplinary teams of researchers, conducting high quality state-of-the-art innovative research, addressing national/international research priorities that will inform and impact on policy and practice. The themes for these programmes are outlined briefly below.

*Environmental and Social Ecology of Human Infectious Diseases (**ESEI**)*

The emergence (and re-emergence) of virulent pathogens remains an ongoing threat to human health. This new initiative aims to establish novel inter-disciplinary approaches to studying the ecology of infectious diseases, in order to better anticipate, prepare for, and control future outbreaks. A holistic systems approach will be required, which takes into account the ways in which the natural and social environments affect the emergence (emergence, re-emergence, and development of drug resistance) and spread of infectious disease. Since most emerging infections are zoonotic, there will be a particular focus on the animal reservoir as a source of infectious disease and how animal pathogens spill over into human populations and

spread through communities in the UK and other parts of the world.

*Environmental Exposure and Health Initiative (**EEHI**)*

Vital ecosystem services that sustain life and health are increasingly under pressure from population growth and urbanisation. Adverse health effects result from the degradation of these services in part because water, land, food or air are more often contaminated with pollutants, such as endocrine disruptors, pesticides, drugs, and particles. Furthermore, these stressors often occur in combination with other environmental and dietary stressors, such as increased temperature and a diet low in anti-oxidants. The aim of this new initiative on Environmental Exposure and Health is to provide important new knowledge on the interconnections and pathways between environmental pollutants and stressors, exposures, early effects (for example, biomarkers) and health outcomes in humans, including variations in susceptibility and the definition of health risks. This integrated understanding is vital to inform development of evidence-based policies.

Lessons learned

In some cases we may commission an independent evaluation of a programme, where we feel we need independent evidence, as described in our Evaluation Strategy [1].. If we have not been in contact with you about this, we are still keen to learn lessons and identify best practice, to improve the way that we design and implement Research Programmes and other activities (in accordance with PRINCE project management practice).

It would therefore be very helpful if you could identify in the section below any lessons learned during the programme (innovations/good practice that contributed to the success of the programme, and/or things that in hindsight could have gone better). These may relate to the way the programme was developed, the programme structure and management model, NERC's interaction with the programme during implementation, or the way in which the programme was implemented. You may wish to consult the PIs, advisory bodies and/or key stakeholders.

This section may also include a summary of the Programme structure and management model, key management activities and an assessment of their effectiveness.

The E&HH programme has clearly demonstrated that interdisciplinary teams of scientists from many different fields of interest can work together effectively to generate a vibrant new research community with novel ideas and leading to exciting synergies in previously poorly connected disciplines. There is still some considerable ground to be gained in bringing together clinical and environmental science, however, a significant step has been taken with this integrated research programme. The networks that have evolved as a result of the E&HH Programme are already bearing fruit in a number of successful bids to national and international research programmes, as well as the initiation of the two successor Programmes EEHI and ESEI.

A substantial number of the Principal Investigators and Co-Investigators in the E&HH Programme have gone on to be involved in proposals submitted to EEHI and the ESEI Catalyst Phase. Several new projects have also been funded by the EU as a result of proposals arising from the capacity building element of the E&HH Programme.

The success of this capacity-building Programme has been due in considerable part to the adoption of whole system approaches by many of the project groups. This underlines the need to emphasise the importance and value of systems approaches and integration of the interdisciplinary efforts in future programmes that address interfacial science. The successor Programmes, ESEI and EEHI, have successfully adopted this integrated holistic strategy as a key element of their remit.

The only significant problem encountered related to the need to obtain permissions from Institutional Ethics Committees. This process can often take a considerable length of time, particularly with interdisciplinary multi-institute projects, and resulted in the late start of several of the E&HH Projects. Awareness of this factor should be emphasised at an early stage in the call for proposals in future.

[1] http://www.nerc.ac.uk/about/delivery/documents/eval-strategy.pdf

Conclusions and Recommendations

While the health of the UK, and other parts of the world, has improved considerably over the last three decades, there remains considerable social and spatial difference in ill health distribution. Causal factors have been identified that explain much of this difference for certain diseases (e.g. high cholesterol and insufficient exercise for coronary heart disease). However, a significant proportion of this difference in health burden remains unexplained, such as in cardio-vascular disease, diabetes, obesity and many cancers where environmental factors are likely to be significant [1-7].

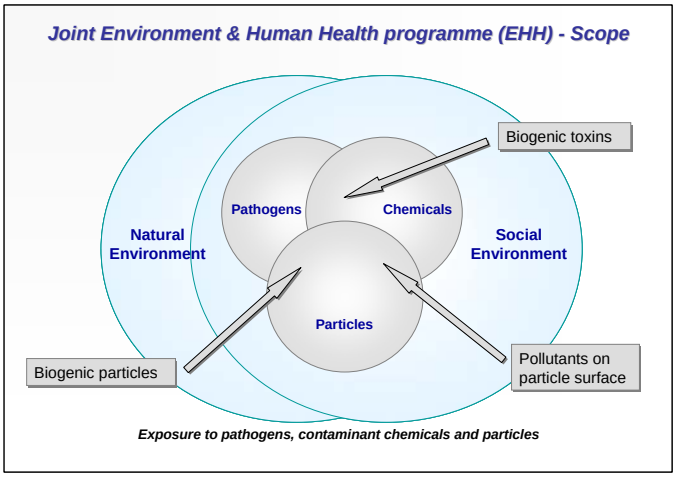

Fig. 1. Diagram showing the scope of the Environment & Human Health Programme showing the interfacial nature of the research and the focus on transport and effects of pollutant chemicals, particles and pathogens. Future research challenges are indicated in the interfacial areas between particles, chemicals and pathogens, which include biogenic toxins from cyanobacteria and algae, harmful particle coatings of microbial origin, and indications that the complex aetiology of diabetes, obesity and various cancers may involve both viral infection and environmental chemical exposure [1 - 7].

Furthermore, we are only beginning to appreciate the possible impact of changes in the climate and global environment on ecosystems and health.

Undoubtedly, new developments and improvements in our scientific understanding of how environmental change impacts on the linkages between ecological integrity, environmental goods and human health will aid us as we seek to develop an acceptable standard of living for many more people. This will in turn help us to ensure that the ecological pillars, which support our society and industries, are protected and remain sustainable. We must also aim to successfully integrate social and natural systems on a local scale, while understanding the larger scale ramifications and consequences of decisions on national and trans-national scales.

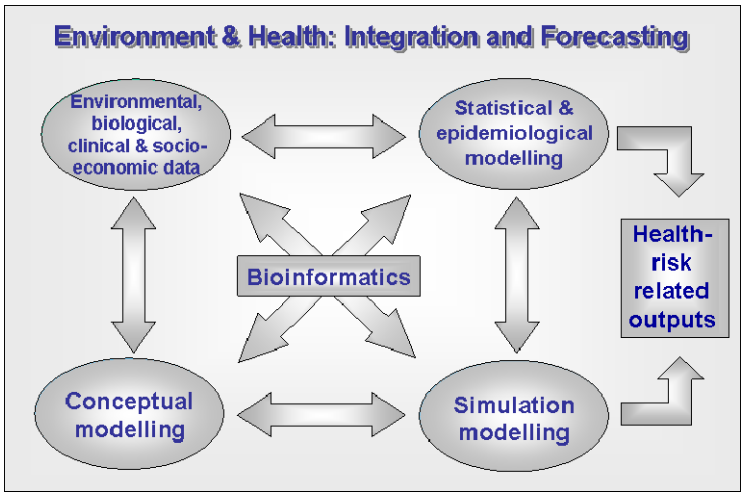

Fig. 2. Holistic systems approach to studying environment and health problems involving multi- and inter-disciplinary biomedical and environmental research. This process-based synthesis facilitates the integration of environmental, biological, ecological, epidemiological and socio-economic data for forecasting risk. To be effectively interdisciplinary the multidisciplinary groupings in a research project need to be highly interactive in addressing the scientific problem.

The Joint E&HH Programme has played a

significant role in taking this agenda forward, not only by bringing together researchers from a broad range of environmental, social and biomedical backgrounds, but also by fostering new relationships with end users and policy makers. This new community is helping to provide the multidisciplinary capacity able to respond in an interdisciplinary way to resolve problems that are intrinsically interfacial in character (Fig. 1).

Many of these issues relate to complex problems such as the environmental biology and geochemistry of soils and how these influence the transport, accessibility and bioavailability of chemical pollutants and infectivity of pathogens. The dispersion of harmful particles in the atmosphere is another area of major concern where the E&HH Programme has broken new ground by showing how the chemical and physical properties of such particles influence their environmental behaviour and may govern their toxicity and resultant pathological reactions induced following inhalation.

A significant aspect of the E&HH Programme has been inclusion of broader socio-economic issues involving people-orientated environmental health-related problems (Figs. 1 & 2). Unfortunately, there remains a relative dearth of substantial epidemiological data that would permit a comprehensive understanding of possible causal links between human and ecosystem health (see - *Millennium Ecosystem Assessment*, 2005, www.millenniumassessment.org/en/index.aspx; and World Health Organization, www.who.int/topics/environmental_health/en/). However, by effectively identifying and interconnecting the interdisciplinary elements, we are beginning to see the emergence of new ways of solving problems in what are, at present, areas of research that have traditionally had little connection with one another (Fig. 2). The E&HH programme has clearly demonstrated the value of supporting the exciting and novel integrative and holistic research which has resulted from the interdisciplinary research groups that it supported (Fig. 2). The success of the programme has fostered the evolution of two new successor programmes (i.e., *Environmental and Social Ecology of Human Infectious Diseases - ESEI*; and *Environmental Exposure and Health Initiative - EEHI*).

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Annexes

1. Science and Implementation Plan
2. Final summary of Projects

3. Science Suppliers
4. List of Awards
5. Annual Programme Reports - Annexes 5.1, 5.2 & 5.3
6. Annual Conferences
7. Publications in "*Environmental Health*"
8. Financial Summary