

Linking changing agroecosystems to human health and well-being: Lessons from the Ecohealth program

A Synthesis Report

Catherine Kilelu
Center File 104742-002

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Executive Summary

Agriculture, farming systems and rural landscapes are undergoing complex transformations with important implications on human health and human well-being, particularly of rural populations who depend fundamentally on ecosystems and their services for livelihoods.

While agricultural transformations and their impact on human health and the environment do not occur everywhere in the same way nor to the same extent, broad trends are still discernable. Some key trends affecting poor rural populations' health and well-being in developing countries include: intensification and/or commercialization of agriculture, loss of ecosystem services and functions, loss of biodiversity, bioaccumulation of toxics and other pollutants, reduced water quality and quantity and soil depletion and degradation, the loss of dietary diversity, degradation of forest and common pool resources, climate variability and change to name a few. Such changes increase the exposure of poor people to negative health effects. This suggests the need to systematically understand the linkages between health, environment and poverty and trade-offs in choices made by all actors to improve both health and agriculture production.

It is in this context that IDRC's Ecohealth program has focused on agricultural transformations and linkages to human health and well-being as one of its strategic thematic areas (Ecohealth, 2000, 2005). Since 2000, the Ecohealth Program at IDRC has supported a robust portfolio of projects on the interactions between agriculture and human health. The purpose of this body of work is to generate scientific knowledge, build capacity and influence policy to mitigate the negative impacts of agricultural transformations particularly for poor, marginalized and underprivileged communities. While programming on this theme has evolved over time, most of the work supported thus far has been focused on three key sub-themes 1. *Environmental contamination*, 2. *Communicable diseases*, and 3. *Access to natural resources for food and nutrition*¹.

So what are the key outcomes and lessons that have emerged from this body of work? To answer this question, the Ecohealth program engaged a consultant² to work with the team to extract and synthesis the more salient findings, learning and impacts of a selected number of projects under this strategic thematic area. The key purpose of this synthesis report is to support overall consolidated team learning and contribute to the Ecohealth Forum to be held in Mexico in December 2008. The review focused on four key outcome areas of the Ecohealth program which include: i) improved holistic knowledge on the links between environment and human health, ii) effective multi-sector interventions and informed policy making and implementation for improved health and well being outcomes, iii) capacity development and iv) knowledge sharing and networking.

Methodology

Eight Ecohealth projects (listed in annex 2) from the overall portfolio classified under the agriculture transformation theme and implemented between 2000- 2007 were reviewed. The projects were purposely selected in discussion with the Ecohealth team based on a number of criteria that include the stage of completion, regional representation, and diversity of the

¹ with a fourth major sub-theme recently developing on *Health and adaptation to climate change*. Projects under this sub-theme have only recently been developed and were not reviewed for this paper.

² See Annex 1 for the Consultancy ToRs

sub-thematic areas under the rubric of the agriculture transformation theme area. The data source included project reports (final and interim), peer reviewed publications, project completion reports and evaluation reports. The analysis is mainly a document review, complimented by discussions with Ecohealth programme officers.

Summary of the outcomes

Outcome 1: Improved knowledge on links between agriculture transformations and human health and well-being.

Although there is a growing understanding that ecosystem goods and services are core foundations of life and health, the casual links between environment and health are generally poorly recognized as they are-- for the most part-- indirect, displaced in space and time and dependent on a number of modifying forces (WHO, 2005). The project results indicate the Ecohealth program has therefore cut its own niche in this area, providing significant new knowledge through the identification of social, economic and governance structures and processes, as well as people's attitudes, behaviour and relations to agro-ecosystems transformation and the links to human health and well-being, thus providing a better understanding of constraints and possibilities for change.

The three pillars of ecohealth—transdisciplinarity, stakeholder participation and social and gender equity are critical for understanding these complex linkages, but not without challenges. A trans-disciplinary approach produces data and outputs that are diverse and impressive in scope yet the recurrent challenge for some of the projects has been how to make sense of the data in an integrated and holistic manner and in developing a coherent team voice with a common language and shared principles. Some projects require more analysis and synthesis to provide conclusive results. Indeed, it is possible to say that an ecohealth approach produces more questions than answers by uncovering a vast and expanding series of questions needing further investigation and posing issues of resource availability (time and money) for the research.

The relevance of social and gender considerations comes out clearly in these projects, although some projects were more successful than others in incorporating this analysis (projects applied PAR and transdisciplinary approaches in different ways). Paying attention to issues of social and gender equity enables two things: contribution of the project itself to social justice and improving project efficiency and effectiveness. Not only are various groups represented and heard in defining the problems and the solutions, but such an analysis also unearths new questions and answers which also require attention and action.

Overall, the projects have produced extensive new knowledge in various areas including a) complex ecosystem mapping to contextualize the problem in relation to agriculture transformation b) an examination of health effects related to changing agriculture production systems and c) testing and measuring the impacts of interventions. The analysis also shows that is more room for learning about how to strengthen research projects that fully espouse transdisciplinary, stakeholder participation and social and gender equity.

Outcome 2: Testing effective and innovative multi-sector interventions and policy influence.

The Ecohealth program support for research is not an end in itself but a means to an end. The program's emphasis is on participatory action research for development, where the research outcomes produce the needed evidence base for policy and/or practical action for better health and environmental outcomes. Consequently, Ecohealth projects incorporate the designing and testing of multi-sectoral and actor driven interventions and provide policy directions through forging much needed alliances along the way as part of the research process with unlikely actors such as between agriculture and health specialists, for example.

The most important policy achievements of all the projects reviewed has been to broaden the public and institutional understanding of ecosystems as complex units of analysis that comprise social, economic, environmental and health determinants.

All the projects have produced and disseminated knowledge at various levels (local to global) through workshops, conferences and publications in scientific literature and otherwise (peer and not peer reviewed). What emerges from this body of projects is that getting to the level of testing and evaluating interventions requires long- term project horizons and in many cases more funds. This is clearly demonstrated from the projects reviewed where it is only at the second phase that projects begin to move away from characterizing the issue to testing interventions. However, on the policy arena, the project outcomes indicate the non-linearity of policy processes-- in some cases that policy outcomes may occur further down stream once results are conclusive or that they can be fed into policy process even at very preliminary stages.

Several lessons have emerged from the projects. First, the critical importance of building social capital to support intervention efforts cannot be overemphasized. When confronting such complex and embedded challenges of the links between transforming agro-ecosystems and human health, building social capital is just important as developing specific technological interventions. As the projects illustrate, most of the problems are related to behavioural, institutional and governance issues and addressing these problems can best be achieved by leveraging social capital. Another lesson learnt is the importance of developing a robust evaluation framework to assess the effectiveness of these interventions, including evaluating policies options and their related outcomes.

Outcome 3: Capacity building for researchers and other stakeholders

Since the IDRC Ecohealth program also seeks to build research capacity, this review showed that the multidimensional nature of the ecohealth approach actually lends itself to a broader capacity building agenda, targeting research teams and their institutions, as well as other key stakeholders including community and decision makers. In all the projects reviewed, considerable amount of resources were allocated to building the capacity of the team and project stakeholders to do ecohealth research and engage in social learning. Although working in a transdisciplinary team has its challenges, a sentiment echoed throughout various projects is the important shift that occurs in thinking and attitudes of working collaboratively

across disciplines in an ecohealth project. Achievements in capacity building are also noted in the area of formal support to young researchers working with the ecohealth approach. This was achieved through graduate training (Masters and PhD) and internship opportunities. Capacity building also occurred in this portfolio of projects with other critical stakeholders, beyond the researchers themselves. The projects facilitated the engagement, knowledge exchange and the social mobilization and empowerment of other stakeholders.

Outcome 4: Facilitating local, regional and global partnerships

The community of researchers and practitioners engaged in ecohealth research is growing, which in turn is accompanied by the need to foster linkages and networking for knowledge exchange and for opportunities for capacity building, dialogue and advocacy on ecohealth issues. The projects reviewed are part of broader partnerships and networks that are coalescing around environment and health issues throughout the world. However there are key lessons that require attention, particular around the challenges of building effective, robust and sustainable partnerships across institutions.

Conclusion

As global agricultural production grows exponentially to meet the increasing demands for food and overall economic development, it is prudent to say that research and development efforts must be pursued through the support of sustainable production systems that mitigate against negative health and well being impacts while reducing poverty. The results from these agricultural transformation projects provide some of the evidence needed to show that transforming agriculture systems have an effect on the ecosystem which in turn can negatively impact human health and well being and erode some of the benefits that might accrue from the increased agricultural production. It is therefore important to reduce the environmental footprint of shifting food production systems, and the accompany risks to human health i.e there are win- win situations and good practice that can be capitalized on as some of the projects reviewed show.

Importantly, the analysis of these projects confirms that the added value of the ecohealth approach lies in its focus on understanding the social, political, economic and ecological context of-- and on efforts to-- achieve improved health by engaging a multiplicity of actors, processes, and agencies implicated in these complex linkages. The project results confirm the linkages and nested hierarchies that include local, national, regional and even global connections that mediate agriculture production systems. The outcomes of this portfolio of projects also shows that addressing the resultant effects of health and environment linkages in most instances requires integrated policy responses and institutional support. The most important policy achievements of all the projects reviewed has been to broaden the public and institutional understanding of ecosystems as complex units of analysis that comprise social, economic, environmental and health determinants etc. This holistic understanding exposes the need for more systemic and intersectoral policymaking. Thus, these projects are contributing to broadening policy horizons and placing new ideas on policy agendas. This shows the imperative need for researchers to continually engage in policy arenas in order to their results to provide the evidence base that can have far-reaching impacts

The projects illustrate that the presence or absence of human diseases, while obviously an important indicator of human health, may not often be the best measure of overall human wellbeing. More complex social and environmental determinants of well-being are equally important but much more difficult to study since they are imbedded in the complexity of poverty, malnutrition, powerlessness, and environmental degradation. In closing, it is important to note that inherent to the Ecohealth work is a strong commitment to give people and communities the power, capability and access needed to change and improve their lives; to changing human behaviour and organization, and the associated relationships they create toward the environment; and to work towards more accountable, responsible, and transparent governance on issues that link health and environment (Ecohealth, 2005). The projects reviewed have individually and collectively contributed to this important goal in various and important ways.

1. Introduction

Since 2000, the Ecohealth Program at IDRC has supported a robust portfolio of projects, and networking for knowledge sharing among them, on the interactions between agriculture and human health (Ecohealth, 2000, 2005). The purpose of this body of work is to generate scientific knowledge, build capacity and influence policy to mitigate the negative impacts of agricultural transformations in poor, marginalized and underprivileged communities.

The supported work seeks to provide a more holistic understanding of the complex interactions between human beings and agro-ecosystems which humans depend on for sustenance and resultant consequences on these interactions that affects human health in many ways related to disease, food quality and quantity, chemical pollution and occupational health. This new knowledge, then, aims to inform interventions (policy and practice) to improve health and well being through effective agro-ecosystem management (Ecohealth, 2000).

While programming on this theme has evolved over time, most of the work supported thus far has been focused on three key sub-themes 1. *Environmental contamination*, 2. *Communicable diseases*, and 3. *Access to natural resources for food and nutrition*³. The over-arching hypothesis of this body of work is that better agro-ecosystems management has the potential not only to reduce health risks but also contribute to enhancing human health in a cost affective manner (Ecohealth, 2000).

This paper aims to extract and distil salient achievements and lessons that have emerged from this robust portfolio, particularly focusing on how projects results thus far have contributed to the four key outcome areas of the Ecohealth program which include: i) improved holistic knowledge on the links between environment and human health, ii) effective multi-sector interventions and informed policy making and implementation for improved health and well being outcomes, iii) capacity development and iv) finally knowledge sharing and networking.

2. Background

Agriculture, farming systems and rural landscapes are undergoing complex transformations with important implications on human health and human well-being, particularly of rural populations who depend fundamentally on ecosystems and their services for livelihoods. Agriculture affects the health and well being of rural populations (farmers, workers and their families), and in turn, their health affects agriculture (Hawkes and Ruel, 2006).

The WHO estimates that 24 per cent of global human disease burden is caused by the environmental factors, whilst the Millennium Ecosystem Assessment clearly shows the close linkages between ecosystem services and human wellbeing, part of which are related to agriculture production systems (WHO, 2005). The World Development Report (2008) also recognizes the importance of understanding the linkages between agriculture and health in order to yield significant welfare benefits.

³ with a fourth major sub-theme recently developing on *Health and adaptation to climate change*. Projects under this sub-theme have only recently been developed and were not reviewed for this paper.

While agricultural transformations and their impact on human health and the environment do not occur everywhere in the same way nor to the same extent, broad trends are still discernable. Some key trends affecting poor rural populations' health and well-being in developing countries include: intensification and/or commercialization of agriculture, loss of ecosystem services and functions, loss of biodiversity, bioaccumulation of toxics and other pollutants, reduced water quality and quantity and soil depletion and degradation, the loss of dietary diversity, degradation of forest and common pool resources, climate variability and change to name a few. Such changes increase the exposure of poor people to negative health effects. Examples include increased exposure to pesticides and other agrochemicals, exposure to vector borne diseases, increased vulnerability to old, emerging and reemerging diseases such as HIV/AIDS and avian influenza and malnutrition due to limited access to quantities and diversity of healthy and nutritional food. This suggests the need to understand the linkages between health, environment and poverty and trade-offs in choices made by all actors to improve both health and agriculture production.

It is in this context that IDRC's Ecohealth program has focused on agricultural transformations and linkages to human health and well-being as one of its strategic thematic areas (Ecohealth, 2000, 2005). Fundamentally, this body of work examines the complex interplay between changing agriculture practices and other forces (land use changes, environmental degradation, the increase use of agricultural technologies and inputs as a result of intensification, changes in climate, and integration into wider economic global spheres, changing demographics and labour dynamics, changing livelihood strategies), and the effect of these shifts on human health and well-being and the ecosystems on which they depend on. Disentangling these complex linkages consequently contributes to pro-poor policy relevant knowledge that can improve on the twin goals of improving health on the one hand and agricultural production and ecosystem sustainability on the other.

3 IDRC's Ecohealth Program

IDRC has had a long programming history on the interdependent nature between human health and environmental degradation. Currently, the Ecosystem Approaches to Human Health Program (Ecohealth, 2000, 2005) continues to pursue this work. It encourages the development and use of integrative and holistic frameworks that explore the relationships between various ecosystem components to define and value the priority determinants of health and human well-being, recognizing that there are inextricable links between humans and their health with their surrounding biophysical, social, and economic environments. (Ecohealth, 2000, 2005).

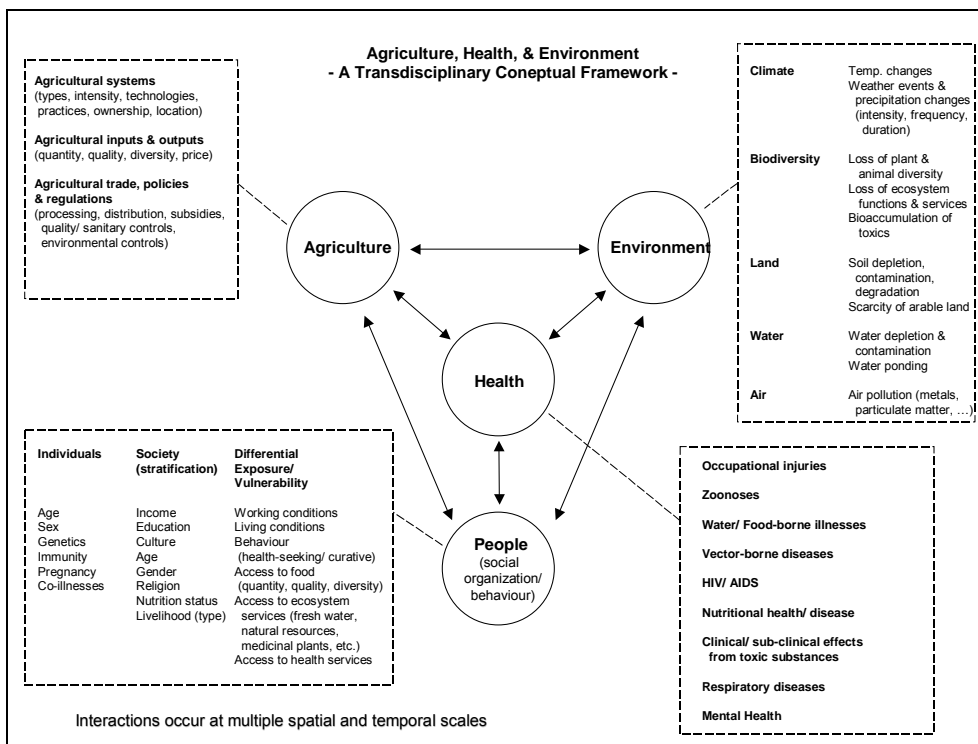
This body of work actually takes its cue from Agenda 21, the action plan for sustainable development. The approach seeks to grapple with complexity by purposely moving away from conventional reductionist approaches towards the integration of multiple perspectives of many disciplines to create a new holistic and realistic synthesis of understanding.

The Ecohealth approach has three core elements or pillars: *transdisciplinarity*; *social and gender equity*; and *stakeholder participation* (Lebel, 2003). **Transdisciplinarity** implies an inclusive vision of ecosystem-related health problems. A transdisciplinary approach enables researchers from different disciplines and key actors to work together effectively to solve a

complex problem, while preserving the richness and strength of their respective areas of knowledge. **Stakeholder participation** is critical because of the recognition that there can be no meaningful and sustainable development without the inclusion of the various stakeholders, particularly of community members, in research and development processes. In the same vein, the Ecohealth approach recognizes the importance of understanding the **social contexts** of the communities where the research is conducted. For this reason, ecohealth research pays close attention to the differences of experiences of men and women, rich and poor and indeed all other dynamics determined by social, cultural and economic factors. Understanding the qualitative and quantitative differences between various social groups helps contribute to social justice on the one hand and improves the effectiveness and efficiency of program delivery on the other. These elements are key to improving health and well-being as they allow for an understanding of change that explicitly links interacting sub-systems (Lebel, 2003, Nielsen, 2001).

4. Agricultural Transformation and Linkages to Human Health and Well Being: A conceptual framework

Causal pathways linking people's health, agriculture and environment are complex. They are often not linear or direct, and can involve multiple interacting processes with feedback loops and different time and spatial scales. Examining agro-ecosystems as the context for development suggests that these ecosystems cannot be seen as stand alone systems but as hierarchically linked: from a local environment of soil, water and biota to the next level of crop fields and paddocks, all the way up to regional agro-ecosystems and national policies and markets, and finally the global level of international trade and policies. Research and analysis and action thus have to be aware of major features in each level and also understand and address the linkages between them, with the purpose of promoting a holistic understanding of these interactions and their implications to ecosystems and human health and well-being (Ecohealth, 2005). The figure below presents a conceptual framework that underpins the Ecohealth programme's thinking about these interrelationships.



Sanchez A, Ecohealth program internal document.

5. Methodology for the review

Eight Ecohealth projects (listed in annex 1) from the overall portfolio classified under the agriculture transformation theme and implemented between 2000- 2007 were reviewed. The projects were purposely selected in discussion with the Ecohealth team based on a number of criteria that include the stage of completion, regional representation, and diversity of the sub-thematic areas under the rubric of the agriculture transformation theme area. The data source included project reports (final and interim), peer reviewed publications, project completion reports and evaluation reports. The analysis is mainly a document review, complimented by discussions with Ecohealth programme officers.

Limitations of the analysis

As a synthesis paper, a trade off has had to be made. Rather than an in-depth presentation and listing of specific project results, the decision has been made to provide an aggregated, meta-analysis of the results and outcomes from these projects. The purpose is to provide an overall picture and analysis that captures the contribution of the ecohealth approach in enriching understanding of the links between agriculture and human health and the resultant interventions paying attention to the lessons learnt from these projects. However, this analysis has been limited by several factors. One limitation was language. The reviewer has little understanding of French and no knowledge of Spanish, which limited the review to projects with documentation available only in English. This reduced the number of projects that were reviewed. In addition, substantive results on interventions and policies were

typically found in projects that had multiple phases, hence the analyses of these outcome areas are derived mostly from these projects, with only some reference to phase one projects or projects that have been recently initiated. The reviewer relied solely on document reviews and did not visit projects in situ or hold discussions with the project teams and other stakeholders which may have provided data not provided in project documents or resulted after project documents were submitted. The reliance on only one source of information also does not offer an avenue for triangulation of the results and findings.

Overall, the projects reviewed have attained different levels of results, and provide different elements to distil and reflect on as lessons learnt. It is important to note that this paper complements and adds to other broader analysis of the lessons learnt by the program mostly conducted through program evaluations that go beyond the agricultural transformation thematic entry point.

6. Results: Synthesis of Outcomes and Lessons learnt

6.1 Outcome 1: Improved knowledge on links between agriculture transformations and human health and well-being.

Globally, agriculture systems and practices are undergoing complex changes, mainly as a result of a push for intensification in production, in efforts to meet the world's increasing demand for food. The understanding of these complex changes in farming systems has mainly been compartmentalized with a focus on ecosystem changes and only in some cases has the health dimension to these changes been emphasized. Although there is a growing understanding that ecosystem goods and services are core foundations of life and health, the casual links between environment and health are poorly recognized as they are for the most part indirect, displaced in space and time, and dependent on a number of modifying forces (WHO, 2005). The Ecohealth program has therefore cut its own niche in this area, providing significant new knowledge through the identification of social, economic and governance structures and processes, as well as people's attitudes, behaviour and relations to agro-ecosystems transformation and the links to human health and well-being, thus providing a better understanding of constraints and possibilities for change. This section highlights some of the results from a diverse portfolio of projects to illustrate the contributions of the Ecohealth program and the lessons learnt.

6.1.1 Agriculture production systems, pesticide pollution and health: two examples from Ecuador

In Ecuador, two Ecohealth projects have advanced the understanding of the negative ecosystem and human health implications of agricultural transformation. In Carchi, northern Ecuador, an inter-institutional project led by the International Center for Potatoes (CIP) brought together a trans-disciplinary team of scientists from economics, epidemiology, sociology, anthropology, soil science, medicine and development fields to examine the effects of intensification of potato farming resulting from a growing potato processing industry and more recently increased fast food consumption in urban areas in Ecuador.

Accompanying this intensification and commercialization has been an increase in the use of chemical pesticides by smallholder farmers who dominate potato production. Ecuador has no national pesticide industry and therefore wholly relies on imports. Large international companies have actively supported pesticide use with support from the Ecuadorian government through a broad range of policies. The pesticides used include organophosphorus insecticides, such as methamidophos, and carbamate insecticides, like carbofuran, with high WHO toxicity ratings (Yanggen et al, 2004; Cole et al, 2007).

Applying a transdisciplinary approach, the project conducted various studies including health studies of the incidence of pesticide poisonings and the neurological impacts of pesticide exposure on farmers and their families; environmental and personal exposure studies; economic studies on the role of pesticides in agricultural production; sociological studies of farmers' attitudes and knowledge.

This participatory action research project has been instrumental in advancing the understanding of the health effects on the poor farmers of increased pesticide use, including pesticide poisoning and long-term neurotoxic effects of pesticide exposure but also the socio-economic and environmental costs in Carchi, which has the highest level of pesticide poisoning in the country. The results indicated that high health care costs and lost work time outweigh the benefits of pesticide use. Farmers who focused on naturally preventing or suppressing pests and used pesticides only when necessary substantially reduced exposure to pesticides while maintaining high potato yields. Interestingly, the results also indicated that intensive potato production and higher incomes do not necessarily correspond to improved health status of the families. The study found mixed outcomes including a deficit in protein intake in children from communities with more intensive systems than among intermediate and less intensive systems. Inversely, the prevalence of moderate chronic malnutrition was greater among children in communities with less intensive systems than among those with intermediate and intensive systems (Cole et al, 2007 Orozco et al, 2007, Yanggen et al 2004).

Gender and social analysis—one of the pillars of Ecohealth, added an important dimension to the project outcomes. An examination of the pesticide contamination pathways in the home helped identify some previously unexamined exposure pathways. Although it was men who primarily applied pesticides in the field, women—who were thought to be safe-- were also exposed through washing pesticide soaked applicator work clothes. In addition, a social analysis found that the poor, small farmers were more exposed than large landholders because the latter hired poorer day labourers to apply pesticides, thereby augmenting that group's exposure risks (Yanggen et al, 2004).

The project tested integrated pest management (IPM) as an alternative approach to traditional pesticide use. An evaluation of the farmer field school (FFS) interventions used in promoting integrated pest management (IPM) showed significant difference between participating and non-participating households with regard to increased pesticide knowledge and less pesticide application. A health assessment, that included a set of neurobehavioral tests, also indicated that farmers who participated in the FFS showed improved neurobehavioral scores, although it was concluded that more testing at a wider scale was needed with multiple communities to improve the quality of the evidence (Cole et al, 2007).

Another project carried out by Centro de Estudios Y Asesoría en Salud (CEAS) focused on

the growth of export cut flowers production in the Granobles Basin in Northern Ecuador, a typical case of agro-industrial expansion. Although this agro-industry occupies a small percentage of the land in Ecuador, it has resulted in far reaching effects on the ecosystem and human health and on the socio-cultural landscape (CEAS, 2005). The research team also covered various fields including in ecology, economics, agronomy, biology, epidemiology, chemical engineering, sociology and phytopathology.

The project ensured extensive stakeholder participation, involving local leaders, municipal government representatives, experts from the ministry of health and environment, flower workers, women organizations, members of the regional health system and some flower entrepreneurs in all phases of the project: from the proposal development and project design phase to implementation and project closure. The project conducted extensive studies and gathered data that offered preliminary, but nevertheless telling results showing the multifaceted and complex nature of health and agriculture linkages in relation to the growing floriculture agro-industry.

Extensive economic and socio-cultural characterization studies entailed the characterization and spatial localization of pesticide intensive floriculture production, the economic and cultural transformation of the community and the social composition of the study area. Through geo-ecological and agricultural mapping, the research team developed a methodology for differentiating flower production areas by type and identifying sampling points to differentiate pesticide contamination attributed to floriculture in comparison to highland agriculture.

The results showed important levels of pesticide contamination of water, plus alterations of water quality parameters. Through this study, the team developed a consolidated geo-codified database on the impacts of cut flower production to aquatic systems and soils. This information is useful for both communities and different government agencies. Currently, the research team is working with the stakeholders to devise and test various interventions (CEAS, 2005; Breihl, 2005).

A novel dimension of this project has been the application of what is referred to as a critical social epidemiology approach (Breihl, 2005; Breihl, 2008). This approach recognizes health as complex and multi-dimensional requiring multiple innovative methodologies. This approach is also critical of traditional, linear epidemiological methods that are opposed to multi-causal models for explaining health conditions. Using a critical epidemiology approach, the research team from CEAS conducted various studies to understand the health and well being risks related to floriculture production. The studies not only focused on individuals but also the collective community. This included a cross-sectional epidemiological study to show various patterns of exposure risks in the flower production systems and worker perceived illness, with a socio cultural dimension that looks at well being determinants that combines a stressors test, a mental illness (suffering) assessment and a personality vulnerability study living that characterize agro-industrial flower work patterns. This study was able to classify the farm sections according to potential health hazards, and interesting results indicate that workers in harvest and fertilization/irrigation areas were at greater risk than those working in the most hazardous sections (i.e spraying and post harvest sections). This was mainly because those in the less hazardous sections had less protective rules and resources.

These project findings have important implications for intervention programs and in understanding who to target, where to target and how to target. The results also indicate high rates of worker perceived illness (e.g. persistent headaches, stomach cramps, dizziness, drooling) indicating that the cases of toxicity are higher than what is on record. The stress test results also show high stress levels and mental suffering. Another epidemiological study examined the association between household and environmental risk factors for pesticide exposure and neurobehavioral development and found that children may be at higher risk than adults from pesticide exposure, due to their rapidly developing physiology, unique behavioral patterns, and interactions with the physical environment. The research team is cognizant of the complex relationships between these risk factors and social characteristics, particularly when countered by some of the socio-economic gains that might result from the floriculture sector. All these factors need to be considered in the analysis (Handal et al, 2007).

In summary, these results have provided a more nuanced and holistic understanding of the problem, and the added value of application of new frameworks, which also open new avenues of inquiry. The results also show that there are socio-economic tradeoffs that involve securing livelihoods on the one hand and ensuring health on the other, pointing to the need for more inter-sectoral interventions and policies.

6.1.2 Farming systems, land use changes, nutritional security and health: Projects from Yemen, Malawi and the Eastern Himalayas

Applying the ecohealth approach also provides useful perspectives to understanding the relationships between enhancing agriculture productivity, the degradation of agro-ecosystems, changing land use systems and the impact all this has on health, food and nutrition insecurity. This is particularly important in light of the more recent and ongoing global food crisis whereby the overall global policy response is to push for increased investments to intensification of agriculture production (World Bank, 2008). The complexity of this challenge may best be understood through the application of systemic approaches as illustrated by the following three projects.

A recently concluded two year project in Yemen led by the Yemeni Genetic Resources Centre of the University of Sanaa on Health and Dietary Diversity, explored how agriculture in the highlands of Yemen have been undergoing rapid transformation and how this transformation may be affecting the health and nutritional status of the poor communities who reside in these marginalized areas. This research is of strong interest to policy makers who are currently caught in a bind: do they help farmers produce more food through encouraging the application of irrigation, chemical fertilizers and improved seed varieties and pay for the environmental and health affects this causes in the long term or do they pay a hefty bill now for huge amounts of lower quality food imports with its associated health costs resulting from reliance on a simplified and unhealthy diet later?. In both cases, there are serious health and nutritional consequences for people who live in this poor country where health services are extremely lacking and expensive.

The research thus far has indicated that extensive transformation is taking place and traditional food staples are being replaced with lower quality imported foods. Subsidies for imported foods have reduced the relative value farmers can obtain from traditional staple crops, and thus they have reduced investments in maintaining fragile soil and water resources in rain fed areas (Al Hakimi et al, 2005, 2007).

The study compared Arafah and Ribat Al Qalaah, two different ecosystems in the district of Saddah. Arafah relies on rain fed agriculture, and continues a traditional cropping pattern of local wheat as staple food, whereas Ribat has been recently transformed to an intensive agriculture system, relying mainly on irrigation and chemical inputs.

The project has produced ecosystems maps, ethnographic information of the indigenous and traditional cereal and pulse legume-based agricultural production and food system, combining wheat-barley-sorghum, and provided an account of ancestral water conservation and seed techniques. The active engagement of women in the project and defining their role in preserving indigenous knowledge on traditional foods and their preparation, diet and health was an important contribution of the project. The results thus far indicated that agriculture intensification coupled with diminishing traditional conservation practices has affected soils, water quality and biodiversity (Al Hakimi et al, 2008).

Through extensive engagement with the communities, the multi-disciplinary research unearthed important knowledge regarding agro-biodiversity in the region and the factors contributing to their erosion. The results also indicated a shift from the consumption of locally produced food to an increased dependence on markets to meet rural household dietary demands. The effects of this shift are reflected in the quality and diversity of the diet. While much more research is needed, it is possible to question whether this shift may be responsible for the observed increase in the so called “modern diseases” such as diabetes being observed in Ribat. Nevertheless, water and environmental pollution and poor hygienic practices were found to be the main causes of the main health problems in the region (Al Hakimi et al, 2008).

Overall, the project has received significant attention from the national policy makers but more work will be needed to provide the needed conclusive evidence. While the project produced large amounts of data, the team found it challenging to do holistic and integrative data analysis and synthesis, which meant that making inferences on the ecosystem and health impacts in the two regions was a challenge for the team. An evaluation of the project outputs and outcomes points out to issues of data quality and some drawbacks with some of methodology applied, making it difficult to assess the quality of the conclusions drawn (Batal, 2008). These challenges can be attribute to short life span of the project. This time was enough to create a multi-disiplinary team, characterize and map the ecosystem, tease out some relationships and their complexity, produce some new knowledge and confirm some hypothesis and even capture the interest of policy makers. But beyond develop the capacity of team and empower some members of the community, more time in needed to conduct thorough analysis and consolidate results.

In Malawi, development strategies since independence have focused on improving productivity of land and labour in the agriculture sector, the majority of which is dependent on smallholder farming. The policy push has been for intensification in production of staples

(principally maize) (Chirwa et al, 2006, Bezner-Kerr and Chirwa, 2004). However, food insecurity is rampant in Malawi as majority smallholders grapple with challenges of producing enough food from small and fragmented land holdings with declining soil fertility, and the inability of most farmers to access credit for inputs. Fertilizer use in Malawi has remained low for over a decade, due to rising living costs and removal of fertilizer subsidies (Snapp et al., 2002 in Bezner-Kerr and Chirwa, 2004).

Recognizing this increasingly precarious situation for smallholders, the Soils, Food and Healthy Communities (SFHC) project based at Ekwendeni hospital in northern Malawi employed an ecohealth approach to examine multiple linkages between environmental aspects such as soil fertility, household and community dynamics in relation to agriculture, gender relations and the resultant effects on the health, particularly of children under 5. The project was initiated in 2000 and has recently completed its second phase. It has resulted in impressive research and development outcomes. The project utilized farmer research teams (FRT), based on the participatory model in which small farmer groups carry experiments themselves with different legume options and then disseminate their findings to the broader community. Gender and social considerations were well embedded in the research design and implementation of this project, ensuring all social groups were represented in the FRT including women, youth, the elderly, widows etc. (Bezner-Kerr and Chirwa, 2004, Bezner Kerr et al, 2007).

The participatory action research tested the efficacy of various legume options for resource-poor farmers for the improvement of soil fertility, food security, and child nutrition. The FRT conducted on-farm trials with various legume options. Using locally developed community indicators, the results from the project showed that food security and child nutrition were factors in legume option choices. Furthermore, the results showed that although there is a critical link between soil fertility, food security and malnutrition, increasing production alone did not lead to improved child nutrition. In the case of improving child health, household and gender relations and power dynamics in extended families were critical factors for consideration. For example, it was found that paternal grandmothers yield a lot of influence in child feeding practices and need to be considered when devising health promotion activities (Bezner Kerr et al, 2008). Additional results also indicated that the choice of legume options for soil fertility management are linked to factors such as labor requirements, markets access and food security considerations, particularly for women and when these are combined with other innovations including nutrition, education and outreach, they can affect children's health.

In the second phase, the project measured the impacts of changes in agricultural practice including improved soil fertility and increased legume production on food security and improved dietary diversity. Further, results indicated how agricultural and nutrition interventions, and shifting socio-cultural practices have had significant improvements in child growth in the communities that participated longer in the project (Bezner Kerr et al, forthcoming). The project has had an impact on the communities' dietary diversity, crop yield, soil improvement and acquisition of seed for various crops (Bezner-Kerr et al, 2004, 2007; Berti and Kerr, 2008). This project provides important insights about the added value and challenges that accompany participatory research processes, which are discussed in sections below.

This project shows how the participatory model pays off and how social analysis produces results that can affect the design of the intervention such as who to target (paternal grandmothers) and how good scientific design creates solutions –legume options and better soil fertility

An ecohealth pilot project implemented by The International Centre for Integrated Mountain Development (ICIMOD) in the three sites in Eastern Himalaya examined land use changes and the effects this is having on mountainous ecosystems and on human health. The project worked in three different sites in Nepal, Tibet and China. The findings, though preliminary, provide important insights about the complicated linkages between land use change and health.

In Tibet, initial results show that the shifts from traditional nomadic lifestyles to agro-pastoralism to permanent agriculture has led to sedentary village life, which is being associated with a marked change in agricultural production, dietary habits and lifestyle: a decline in spatial mobility, and an increase in food production, which may have significant impact on the health of the local people. The results identifies the mismatch between health problems in the community that are linked to the transition and the response adopted by the government, which is emphasising the building of infrastructure while ignoring local adaptive mechanisms including ecosystem management. This project shows mismatching between problems and solutions sought

In Nepal, the project identified the major land-use changes occurring which included the shortening of fallow periods, commercial vegetable growing and excessive use of chemical fertilizers and pesticides/insecticides. These changes are compounded with problems of poverty and limited access to social services, including health. In Yunnan China, land use changes such as the introduction of commercial eucalyptus plantations, intensified agriculture and infrastructure development is resulting in a variety of health problems including water borne diseases, chronic diseases and sexually transmitted diseases. The results show that the transition/land cover change on human health and well being are complicated, diverse and dynamic. These results are still preliminary and another phase is underway to conduct further analysis (ICIMOD, 2006).

6.1.3 Water Management, Agriculture and Communicable Diseases : Examples from Kenya, Egypt and Morocco

Changes in water management—mainly those associated with introducing irrigation and building dams-- generate ecosystem disturbances that often have dramatic effects on health, particularly on relation to communicable diseases. Ecohealth has supported research that has looked into such water management issues in relation to agriculture development.

In East and Southern Africa (Kenya, Uganda, Tanzania and Zimbabwe), Ecohealth

supported a network⁴ of projects that explored the links between changing agricultural production in relation to irrigation and malaria. All the projects, except the one from Kenya, were in their first phase (not older than two years). They have collected large amounts of baseline data, some of which are indicative of the close links between various environmental features fostering malaria and the household (Bernard and Bradley, 2006). This review focused mainly on the Mwea irrigation scheme project in Kenya, because it was the only project that had gone through two phases, enabling it to conduct a comprehensive study of irrigation and its link to malaria, accompanied by testing various community-based interventions.

The Mwea irrigation scheme is primarily directed towards rice cultivation but also supports substantial cattle population. It therefore combines two major aspects of the interaction of agriculture and malaria: irrigation and livestock. Rapid population growth and increasing demand for food has resulted in expanded acreage under rice cultivation and increased cropping cycles into areas previously not under rice cultivation. Irrigation has altered the ecosystem, producing habitats for breeding the vectors of diseases such as malaria and also altering the socio-economic landscape of communities around the irrigation scheme directly and indirectly with consequences on human health and well being.

This ecohealth project brought together an inter-institutional and transdisciplinary team of researchers who demonstrated the need for a holistic approach in which the complexity of the interactions of the host-vector-parasite triad in relation to a complex agroecosystem, superimposed on a community with related socio-economic factors can be detangled in efforts to improve ecosystem and human health (Mutero et al, 2006, Ng'anga, et al, 2008). The project examined all the likely determinants of malaria in four villages of the scheme, giving a multidimensional picture of the issue.

The research findings confirmed that malaria ranked high as a cause of morbidity in Mwea and was perceived by community to priority health problem (Mutero et al, 2006). A KAP study showed that most households understood the link between the vector (mosquito) and malaria, although some respondents attributed it to non-biomedical causes such as being rained on, eating unripened fruits, or unhygienic surroundings. The project's unexpected finding was the high prevalence of malaria in non-irrigating communities. The most likely explanation for this is what is referred to as 'paddies paradox' where the interaction with livestock provides an alternative blood meal source for the mosquitoes. The results suggested that zoonophylaxis was potentially a practical option for long-term malaria control in the rice irrigated areas (Mutero, et al 2006). An evaluation of the project notes that while these findings are important, they are only indicative and will require larger scale and longitudinal studies to affirm this finding (Bernard and Bradley 2006). Through a characterization of the socio-ecological system in Mwea, the project was able to understand interactions between environmental and socio-economic factors, and how these determined the prevailing picture of malaria endemicity. These findings informed the development and testing of various multi-pronged and holistic intervention strategy that included integrated vector management (IVM) strategy; enhanced awareness and education regarding integrated

⁴ The Systemwide initiative of Malaria and Agriculture (SIMA), was coordinated by International Water Management Institute. See Bradley (2006) for a more detailed assessment of the outcomes of the network.

malaria control; improved community access to facilities for reliable malaria diagnosis and prompt treatment (Mutero et al, 2006).

In El-Fayoum, Egypt, a multi-disciplinary team of researchers from the University of Alexandria are exploring the link between the increased prevalence of schistosomiasis, malaria and other water borne diseases in a large agricultural oasis undergoing transformation. The project—in its second phase-- aims to develop and implement ecologically based resource management interventions to promote community health. The first phase of the project has built a spatial and temporal Eco-InfoBase to assess and predict ecosystem components with community health problems. The assessment of the ecosystem revealed considerable land and water resources degradation, which enhanced the risk of water-borne diseases. The results found that although the disease-carrying vectors of schistosomiasis and malaria were detected in the waterways, the incidence of the two diseases was relatively low, and was not only linked to degraded natural resources but also to broader socio-economic conditions (Kishk et al, 2004, Kishk, et al, 2005). The project is currently developing, testing and assessing the cost-benefit of various interventions for improving the ecosystem and human health situation in several study communities.

In Morocco, researchers from National Institute for Agricultural Research (INRA) have just completed the first phase of a two-year ecohealth project that focussed on the health impacts of government built small dams to provide much needed water in times of drought to small marginalized communities in semi-arid regions of the country. Small dams are constructed as an alternative to large-scale irrigation schemes to increase food production, provide water for domestic use and improve rural livelihoods. In the past, the assessment of dams has been purely a technical task, involving mainly engineers. The ecohealth project was able to expand the considerations of economic, social, ecosystem and health factors in the future planning of such dams. In addition, participatory design and assessment has been embraced and has enabled local stakeholders including local communities to be centrally involved in assessing the impacts of the dams and becoming managers themselves. (INRA, 2006)

6.1.4 Agriculture transformation and zoonoses: Example in Kenya

The livestock revolution in developing countries has been associated with the growth of unprecedented concentrations of animals in the urban and peri-urban areas with major implications for human and animal health (World Bank, 2008). The Ecohealth program is supporting projects that are contributing to understanding the effects of these shifts on emerging and re-emerging diseases⁵.

A recently completed ecohealth project on urban livestock keeping in Dagoretti, Nairobi has helped to shed some light on the tradeoffs between livelihood benefits and health risks associated with the growing phenomenon of urban agriculture. The research looked at the intensification of livestock and the concomitant alteration of the ecological context within which vectors and parasites breed, develop and transmit disease, which has favored the emergence of zoonotic diseases. Cryptosporidiosis has emerged as a critical zoonosis with

⁵ The Ecohealth program has been supporting a portfolio of projects in South Asia looking at Avian Flu. These projects are very early in their implementation and were not included in this review.

cattle as the main reservoir. The project incorporated a transdisciplinary approach, albeit with some challenges. It conducted health, economic, environmental and risk analysis studies to inform policy about how best to improve human health and protect livestock-based livelihoods in Dagoretti, and other similar peri-urban regions in Kenya. The project also conducted prevalence studies to estimate the level of disease in both cattle and human populations and assessed the risk factors in the community informed by participatory processes with strong social and gender analysis. The cross-sectional study of prevalence in both cattle and humans confirmed the importance of cryptosporidium in cattle, although the prevalence among humans was low. However, certain vulnerable population segments including malnourished children and those infected with HIV were considered to be at most risk. The research has made important contributions to guide mitigation strategies to ultimately enhance the benefits and reduce the risk of this very important economic activity (Kang'ethe et al, 2008).

From the summary of results above, we see that the ecohealth approach is making important contributions to local, regional and global knowledge on the links between agroecosystem transformation and human health. The projects use conceptual underpinnings of the ecohealth approach in different ways and add new knowledge in understanding the complex linkages between agricultural and health and well-being. The added value of these projects is the extent to which they go beyond defining agroecosystems as biophysical environments, but show the complex embeddedness of ecosystems in social, cultural, political and economic factors and how these intertwine to affect human health. The three pillars of ecohealth—transdisciplinarity, stakeholder participation and social and gender equity are critical for understanding these complex linkages, but not without challenges. A trans-disciplinary approach produces data and outputs that are diverse and impressive in scope yet the recurrent challenge for some of the projects has been how to make sense of the data in an integrated and holistic manner. Some projects require more analysis and synthesis to provide conclusive results. Indeed, it is possible to say that an ecohealth approach produces more questions than answers by uncovering a vast and expanding series of questions needing further investigation and posing issues of resource availability (time and money) for the research (Batal, 2008; Bernard and Bradley, 2006).

The importance of social and gender considerations comes out clearly in these projects, although some projects were more successful than others in incorporating this analysis (projects applied PAR and transdisciplinary approaches in different ways). Paying attention to issues of social and gender equity enables two things: contribution of the project itself to social justice and improving project efficiency and effectiveness. Not only are various groups represented and heard in defining the problems and the solutions, but SAGA also unearths new questions and answers which require attention and action.

From the above analysis of the projects in this portfolio, there clearly is more room for learning how to strengthen research projects that fully espouse transdisciplinary, stakeholder participation and social and gender equity. Overall, the projects have produced extensive new knowledge guided by the three pillars of ecohealth on various areas including a) complex ecosystem mapping to contextualize the problem in relation to agriculture transformation b) an examination of health effects related to changing agriculture production systems and c) testing and measuring the impacts of interventions.

6.2 Outcome 2: Testing effective and innovative multi-sector interventions and policy influence.

The Ecohealth program support for research is not an end in itself but a means to an end. The program's emphasis is on participatory action research for development, where the research outcomes produce the needed evidence base for policy and/or practical action for better health and environmental outcomes. Consequently, Ecohealth projects incorporate the designing and testing of multi-sectoral and actor driven interventions, forging unlikely but much needed alliances along the way as part of the research process with unlikely actors such as between agriculture and health specialists.

The most important policy achievements of all the projects reviewed has been to broaden the public and institutional understanding of ecosystems as complex units of analysis that comprise social, economic, environmental and health determinants etc. This holistic understanding exposes the need for more systemic and intersectoral policymaking. Thus, these projects are contributing to broadening policy horizons and placing new ideas on policy agendas. This shows the imperative need for researchers to continually engage in policy arenas in order to their results to provide the evidence base that can have far-reaching impacts

All the projects have produced and disseminated knowledge at various levels (local to global) through workshops, conferences and publications in scientific literature and otherwise (peer and not peer reviewed). What emerges from this body of projects is that getting to the level of testing and evaluating interventions requires long- term project horizons and in many cases more funds. This is clearly demonstrated from the projects reviewed where it is only at the second phase that projects begin to move away from characterizing the issue to testing interventions. However, on the policy arena, the project outcomes indicate the non-linearity of policy processes-- in some cases that policy outcomes can occur further down stream once results are conclusive or they can be fed into policy process even at very preliminary stages.

The potato-farming project in Ecuador developed and tested out a variety of interventions. The participatory modality of the project facilitated interactive and negotiated learning between farmers, development practitioners, scientists and decision makers in interventions development and testing. The project interventions were focused on promoting local practices to reduce the dependency and exposure to highly toxic pesticides. At the individual level, Farmer Field Schools (FFS) were important avenues through which the project was able to experiment with integrated pest management approaches, promote safe pesticide handling, sensitize communities about exposure pathways and dangers of the pesticides, which ultimately led to a decreased neurotoxic burden (Yanggen, 2004; Cole et al, 2007). At another level, the project has been instrumental in supporting various fora that brought together local and national stakeholders including ministry of agriculture, representatives of the health and environmental ministries, farmers, pesticide industry representatives, NGOs and researchers, to act on mitigating the effects of pesticide use in the farming communities. These multi-stakeholder forums have been instrumental in engaging with key decision makers at the municipal, provincial and state levels. One such forum was the "Structural municipal reforms needed to promote a sustainable agricultural development - Perspectives for action. It brought together mayors across the country and key local officials in agriculture

and health, as well as decision makers on agriculture, health and environment from Provincial and Central levels of the State government to discuss alternatives for local regulation of agricultural development that included a health and agriculture agenda. One of the participants of this forum was the president of the health commission of the national congress. Influenced by the research results he was instrumental in preparing a congressional resolution aimed at amending the existing laws on the commercialisation and use of pesticides to restrict the sale of highly toxic pesticides in the country. Although the Ecuadorian congress was dissolved before the passing of this resolution into law it provides a concrete example of research-policy linkages (Orozco et al, 2008; Sanchez, 2006).

Another important intervention of this project was at the health system level. The project demonstrated gaps with the surveillance system that under-reports case of pesticide intoxication. As a result, the ministry of health in Ecuador is upgrading its national surveillance system on pesticide intoxications. It is developing the new system with the collaboration of the Provincial Directorates of Health where the project took place and using the project results as a guide. The FAO is funding the implementation of the surveillance system. In particular, the electronic case reporting forms and protocols for treatment and follow up of cases that were developed through the project are being used as models for the country (Sanchez-Bain, 2006; Guimares & Mota 2006, Yanggen et al, 2004).

The project also successfully used an integrated assessment method called the Tradeoff Analysis Model to simulate the effect of alternative policies such as increased taxes on pesticides. Through this analysis, the win-win solution reached was to increase taxes only on the most toxic pesticides and compensate for the marginal increased production costs through taxes. Tradeoff Analysis also showed that both IPM and applicator safety measures improved economic returns, health outcomes as well as decreased environmental contamination. Combining these two technologies improved health and productivity outcomes even further in another example of a win-win scenario (Yangenn, et al 2004).

The project in Malawi was highly successful in testing multisectoral interventions and disseminating knowledge about the role of legumes in improving soil fertility, food security, and child nutrition. Multi-educational activities and participatory research involving farmer research teams was carried out with 80 communities. Over five years, more than 3000 farmers tested legume crops and gained knowledge of their contributions to child nutrition and soil productivity. The average area of expansion of legume systems was 862 m² in 2005; 772 m² for women and 956 m² for men indicating a strong gender dimension to legume adoption (Bezner-Kerr, 2007). The intensive and continued presence of the research team in the field and the integrated approach in research and testing of interventions on agronomic techniques (promotion of new species, intercropping, crop residue burial, seed banks), socio-anthropological work (nutrition education, discussion of roles in the household) and healthcare, have contributed to improved farming practices, changed perceptions and attitudes, with an overall effect on improved health and well being in the community, especially for children and sustainability of the agro-ecosystem. It was clear that incorporating a nutrition education component to the project, fostered discussions within households and communities, the foundation for sustained adoption of legume-diversified systems (Bezner-Kerr et al, 2004, Bezner-Kerr et al 2007).

Interestingly, despite the impressive outcomes of the project at the community level, the policy reach was limited and illustrates the difficulty of engaging with policy makers. It also provides a good example of the challenge of turning research evidence and recommendations from an ecohealth project into public policies, especially when the public authorities are not present throughout the process due to a variety of reasons as discussed in the next section. This is not to say that the project has not been successful. Indeed, the team has also shared the findings with the Ministry of Agriculture, which expressed interest in the outcomes. However, what this gets to at the end is that good results do not necessarily produce policy or institutional change. In addition, though the project has had influence on the institutional practice at Ekwendeni hospital which is now paying more attention to agriculture as a source of health problems and solutions and also altering its approach to nutrition based on the results from the project, it is also not clear whether this can lead to more permanent inter-sectoral linkages between the health and agriculture sectors. Interestingly, the policy reach of the project has been more at the Canadian front. Canadian NGOs that provided some support for this project are using the findings for engaging with current international initiatives and debates around the push for an “African green revolution” (Berti and Bezner-Kerr, 2008) to advocate for holistic approaches to agriculture development in sub-Saharan Africa that not only look at technology and institutional innovations, but also intersectoral and integrated approaches to agriculture development.

The floriculture project in Ecuador developed and tested health monitoring and management systems in the flower farms and alternative toxicity screening instruments. The project designed, tested and initiated a pilot application of software in the health units of 4 cut flower farms that is to be used for standardized occupational history and is then to monitor individual health and farm section conditions so as to measure health outcomes. In addition, the project proposed alternative toxicity-screening instruments after demonstrating the inadequacy of the standard screening methods (AChE)⁶. These are important contributions of the project that can be applied in prevention and control programs. At the community level, the project also implemented an experimental process of improving bioassays⁷ for water chemical contamination assessment. One of the experiments was developed by a community laboratory in efforts to implement a community driven water-monitoring system. Another interesting contribution of the project was the design and validation of Pentox, a community application test for basic screening for exposure and probable effects of chemical agrotoxic agents. On the policy front, the project has provided directions to the international flower trade policy for fair and safe flower certification (by providing critical scientific input to the European Flower Label certification program). Through its innovative work, the project provided guidance on international labour, social and gender justice and ecological protection standards to the industry. It has also contributed to the “Just and Ecological Flower Campaign” in the US (CEAS, 2005).

In Mwea, the project successfully mobilized the community to explore malaria control approaches in line with ecosystemic thinking. These interventions aimed mostly at enhancing behavioural change at both individual and community levels through awareness raising activities. They also included ecosystem management interventions such as draining areas of stagnant water, clearing vegetations in water canals, and destruction of discarded water

⁶ Erythrocyte Acetylcholinesterase

⁷ These were developed through WaterTox- a previous project supported by IDRC..

receptacles; the use of self-protective measures (e.g. treated bed nets) and increasing awareness on the importance of prompt diagnosis and treatment seeking (Ng'ang'a et al, 2008, Labatut, 2008). Educational activities and information dissemination through a training of trainers approach of schoolteachers and community health workers was key. It was also intended that through the ToT, a continuous process for monitoring progress of activities and action plans was devised and used by the community and the researchers. However a key issue for which Mwea is widely known remains the inverse relation of livestock keeping to malaria, the explanation for which is still not clear. The change in mosquito density is but weakly associated with an undramatic gradient in cattle keeping. If well supported with further evidence, this intervention can have far reaching implications including at the policy level, but the data to date are inadequate to use as a basis for policy making, though the ban on cattle is openly flouted on a large scale in the area (Bernard and Bradley, 2006).

The project also developed soya-rice field trials to test the value added of introducing soybeans as a break crop aimed at reducing vector breeding sites, while at the same increasing soil fertility and contributing to the better nutrition in Mwea (Kuria et al, 2006). An economic analysis demonstrated that alternating rice with soy was highly beneficial with respect to increasing household incomes, enhancing nutrition, replenishing soil fertility and improving vector control. If this farming system is to be adopted, it would probably go a long way to improving the ecosystem management of the Mwea irrigation scheme while positively impacting health and contributing to the economic empowerment of the local communities. But curiously, this intervention has not been taken up to scale (Bernard and Bradley, 2006) though more field trials could mainstream this new agricultural practice. Although only preliminary soybean trials were tested, it is still possible to suggest policy guidelines for wider soybean introduction in Mwea, particularly considering the increasing demand for the crop by export markets and the effect of wider production of soybeans might have eventually on malaria control.

The Yemen project results—though only two years old-- also indicate that not having conclusive results does not preclude getting the attention of policy makers, particularly if the issue is “hot”. The project team met with officials from the Ministry of Agriculture to discuss project results and they requested a policy brief from the team. They also requested the formation of a coordinating committee consisting of key stakeholders, including policy makers, to develop a second phase for the project (Batal, 2008). As the project illustrates, food and nutrition security is not only tied to internal agriculture productivity challenges but is linked to broader global trade which must be taken into account to fully understand the problem. This outcome confirms the importance of inter-sectoral approaches to policy making, illustrating the interdependent nature of policies, and the limitations in their extent if they are implemented alone.

From this review, several lessons can be deduced regarding testing effective and innovative multi-sector interventions and policy influence. First, the critical importance of building social capital to support intervention efforts cannot be overemphasized. This reiterates the critical importance of stakeholder involvement at all levels of the project. When confronting such complex and embedded challenges of the links between transforming agro-ecosystems and human health, building social capital is just as important as developing specific technological interventions. As these projects illustrate, most of the problems are related to

behavioural, institutional and governance issues and addressing these problems can best be achieved by leveraging social capital.

Another lesson learnt is the importance of developing a robust evaluation framework to assess the effectiveness of these interventions, including policies and the related outcomes. Testing management approaches which appear to hold promise is critical for propagating ecosystem management for improving health, but, as the projects reveal, it may take a number of years for experience to validate the usefulness of what is being learned.

These results point to some key lessons. First, the outcomes indicate that longer project time lines provide a better chance to develop and test interventions and policies given the complexity of the research problems. We can also deduce that policy influence is not a linear process and sometimes bringing in policy makers at the beginning improves but does not guarantee policy adoption. Furthermore, influencing policy is possible, but in achieving concrete policy outcomes require small and incremental steps and also requires that researchers have the capacity to either take on the brokerage role or mobilize stakeholders who may be able to play this role. However, while policymakers do want to act, they may not be empowered to do so because they do not have the funds or the power depending on the context (eg municipal level government vis a vis central governments).

6.3 Outcome 3: Capacity building for researchers and other stakeholders

Since the IDRC Ecohealth program seeks to build research capacity, the multidimensional nature of the ecohealth approach actually lends itself to a broader capacity building agenda, targeting research teams and their institutions, as well as other key stakeholders including community and decision makers. For some partners and some regions of the world, Ecohealth is a relatively new framework which makes it imperative that capacity building activities be prioritized for those. For others, ecohealth comes more natural and easier to adopt in place of the reductionist and disciplinary approaches of particular fields like agronomy, economics and toxicology, for example. These were teams who were more cognisant of the fact that results from a mono disciplinary approach were not sufficient to address the complex challenges related to environment and health linkages.

In all the projects reviewed, considerable amount of resources were allocated to building the capacity of the team and project stakeholders to do ecohealth research and engage in social learning. This occurred either formally through methodology training workshops of the teams prior to commencement of projects or during project implementation as well as other in house and external training opportunities that were offered throughout the duration of the project. The projects also benefitted from a constant and intensive two-way learning process between ecohealth researchers on the one hand and the ecohealth program officers on the other.

A sentiment echoed through various project reports reviewed for this assignment is the change in the thinking and attitudes of working collaboratively across disciplines in an ecohealth project, especially in relation to developing integrated thinking to design a project to take into account the complex and dynamic interactions between changing

agroecosystems and human health and well being. However, it is also important to note that in many projects, there were tensions amongst team members working in a transdisciplinary fashion, particularly around viewpoints, language and concepts around natural vis-a-vis social sciences (Al Hakimi et al, 2008; Yanggen et al, 2004, Kang'ethe et al, 2008). This challenge is further amplified by the difficulties faced by some projects in accomplishing an integrated analysis of the rich data collected. However, many researchers came out of this project with a better appreciation for other disciplinary view points and of the need for a trans-disciplinary and system approach to address complex realities.

Achievements in capacity building are also noted in the area of formal support to young researchers working with the ecohealth approach. This was achieved through graduate training (Masters and PhD) and internship opportunities. All projects incorporated graduate research and training as part of the project. For example, the CIP potato project offered opportunities for fieldwork internships and graduate thesis supervision to 6 students, the first phase of El Fayoum project produced 3 PhD and 1 MSc graduated, the diary project in Kenya trained 4 MSc students, in the Mwea and Yemen projects one MSc and one PhD student respectively were trained through the project (Crissman et al, 2004, Kishk et al, 2005, Kang'ethe et al, 2008, Mutero, et al, 2005, Al Hakimi et al, 2008). The focus on building capacity of young and up and coming researchers who are trained in systemic research from early is important for the long term goal of institutionalizing ecohealth approaches. Nonetheless, a continuing challenge is on moving beyond training a small cohort of young researchers to broad institutionalization of the ecohealth approach at the various training institutions in curricula.

The project in Malawi derived unique lessons about capacity building in research. Since the beginning, the project had difficulties in attracting trained researchers from the local universities to the team. To resolve this problem, the project recruited community development workers to the core research team. This team was further complimented by the FRTs. This very unusual arrangement required different types of capacity development to different groups such as formal training and capacity building through field mentorship supported by the project coordinator⁸. (Berti and Bezner Kerr, 2008).

Capacity building also occurred in this portfolio of projects with other critical stakeholders, beyond the researchers themselves. The projects facilitated engagement, knowledge exchange and the social mobilization and empowerment of other project stakeholders. In all projects, community groups, NGOs, government departments and others interacted and shared knowledge. In Malawi, using the FRT approach entailed building the capacity of farmers to experiment with different legume options and to mobilize community interest in changing agricultural practice. Farmers received extensive training in leadership skills, and in agronomic and health information (Bezner-Kerr and Chirwa, 2004). The Farmer field schools used in the CIP project were an important avenue for building capacity of community members to change their practices about crop and pest management (Cole et al, 2007, Tracy, 2007; Yanggen, 2004;). In Mwea, the project used a training of trainers (ToT) approach to train schools teachers and community health workers to conduct outreach

⁸ Rachel Bezner Kerr was the project coordinator and was conducting her PhD during phase I and part of phase II. She is currently an Assistant professor at University of Western and continues to work in Ekwendeni

programs and educational activities on malaria control and management.

Overall, the analysis indicates that capacities have been developed at all levels in these projects: the capacities of the research team and students associated with the project, the capacities of project boundary partners, be they NGOs or the community members themselves and there is some evidence to show that even policy makers have also benefitted. Progress has occurred in building specific methodological capacities and more generally on how to convene and support transdisciplinary research, and the different avenues for achieving community participation in research, but there is still a lot more that needs to be improved. The question remains, how successful are these capacity building efforts in the long term and how to they contribute to overall change at the individual and capacity levels? This will warrant in-depth case studies to get to the heart of this question.

6.4 Outcome 4: Facilitating local, regional and global partnerships

The community of researchers and practitioners engaged in ecohealth research is growing, which in turn is accompanied by the need to foster linkages and networking for knowledge exchange among themselves as a group of people with similar interests and goals and to provide support for capacity building, facilitate dialogue and promote advocacy on ecohealth issues.

The projects reviewed here are part of broader partnerships and networks that are coalescing around environment and health issues throughout the world. The IDRC Ecohealth program has responded to the need for building these bridges between local regional and global players and across disciplines by supporting regional communities of practice who are implementing concrete activities. The two projects in Ecuador, for example, are actively involved in the COPEH-Latin America. The teams from Morocco and Egypt are part of COPEH-MENA.

Global partnerships have also been important in propelling knowledge of ecohealth approach. CEAS for example has used its work on the floriculture industry to form the Latin American Health Watch as part of the Global Health Watch. CEAS was involved in producing the first Alternative Latin American Health Report that incorporated work on ecosystem health and has now been invited to be a committee member of the international steering committee of Global Health Watch (CEAS, 2005). Furthermore, all the projects have also sought various opportunities for networking and dissemination of results by participating in international, regional and local conferences, workshops and forums.

As can be expected, there are lessons to be learnt from these projects on partnership building and knowledge sharing. For example, one of the challenges of engaging with multiple stakeholders in ecohealth projects is the competing interests between researchers and practitioners. Guimares and Mota (2006) illustrate this issue through their analysis of some of the tensions in the CIP project in Ecuador. They highlighted the tensions between researchers and community members in balancing the project's research and intervention objectives. Some stakeholders saw the project as a burden—especially the time and effort required for data collection, which reduced their willingness to participate. This in turn caused some disappointment for the research institutions (Guimares&Mota, 2006). However

looking at the impressive scientific outputs and the intervention and policy outcomes, it seems the project was able to reach a good balance in the end.

In Malawi, where the approach was very much bottom-up, the project was not successful in developing the partnerships it had anticipated, including with other research institutions and government agencies. This was due to several factors, including the remoteness of the project site making it inaccessible to the highly centralized government officials, and because of limitations imposed by one of the hosting institutions, the Presbyterian church, which put a cap on the remuneration allowed for researchers thus making it difficult to attract potential researchers from the local university to the project. As Guimares and Mota (2006) note, the fact that there were fewer stakeholders in the project forced the team to focus its interaction mostly with the direct beneficiaries—which led to a simplification of the institutional setting that had-- in turn-- many advantages, such as more stability and control. But this came at the cost of assuming a burden that would normally be shared (or disputed) by many different actors. Nonetheless, the project team was cognizant of the added value of forming broader partnerships that are useful for long-term sustainability and scaling up of such an initiative. In its second phase, the project set out to develop more partnerships, mainly through targeting graduate students, particularly Malawian students, but this again was a challenge. Furthermore, while the project was successful in developing partnerships with the local communities, some tensions emerged between the FRT and village committees formed to mobilize farmers mainly because of perceptions around leadership and resultant benefits that were accrued with these roles. This required the core team to spend a lot of time resolving conflicts (Bezner Kerr and Chirwa, 2004). These issues raise some important concerns that are worth more reflection, particularly around how to conduct effective participatory research and how to form and sustain effective partnerships based on a more thorough and nuanced understanding of the power dynamics among stakeholder groups.

7. Conclusions

This synthesis paper captures the achievements and challenges of a group of Ecohealth projects falling under the agriculture transformation sub theme. The projects varied in theme, scope, duration, and location and in the problematique addressed, methodologies used, outcomes expected and results and impacts evaluated. Separately and collectively, the projects have contributed to producing a rich body of knowledge and providing a more holistic understanding of the linkages between agriculture transformation and the effects of these changes on human health and well being.

As global agricultural production grows exponentially to meet the increasing demands for food and overall economic development, it is prudent to say that research and development efforts must be pursued through the support of sustainable production systems that mitigate against negative health and well being impacts while reducing poverty. The results from these projects provide some the evidence needed to show that transforming agriculture systems have an effect on the ecosystem and can in turn negatively impact on human health and well being, and inversely erode some of the benefits that might accrue from the increased agricultural production. It is therefore important to reduce the environmental footprint of shifting food production systems, and the accompany risks to human health i.e there are solutions and win-win situations as shown above.

Importantly, the analysis of these projects shows that the added value of the ecohealth approach lies in its focus on understanding the social, political, economic and ecological context of-- and on efforts to-- achieve improved health by engaging a multiplicity of actors, processes, and agencies implicated in these complex linkages. The project results confirm the linkages and nested in hierarchies that include local, national, regional and even global connections that mediate agriculture production systems. The project results provide the compelling evidence of these linkages and offers insights to show that even as the agriculture systems shifts, judicious management of agroecosystems can reduce the negative effects of these transformation on human health, through multi-sectoral interventions and policies.

The lack of coordination of policy making between sectors like agriculture and health undermines efforts to overcome ill health among the rural poor and gives short shrift to agriculture's role in alleviating many of the world's most serious health problems (World Bank, 2008). Yet there is evidence that coordination and cooperation across sectors is possible like some of these projects but not without a cost.

The outcomes of this portfolio of projects also shows that addressing the resultant effects of health and environment linkages in most instances requires integrated policy responses and institutional support. The review indicates some of the various opportunities ecohealth projects have had in broadening policy horizons particularly through networks and partnerships that have created conditions for affecting policy regimes through stimulating interest and dialogue on health and agriculture. But there is still much more work that can and must be done in this area.

There are other lessons that have emerged from this synthesis. Conducting ecohealth research, which is layered to include transdisciplinarity, stakeholder participation and consideration of social and gender equity, requires that researchers develop different complimentary practical and theoretical capacities. This can occur only when a multi thronged capacity building approach is adopted and includes formal training, learning by doing and complimented by continuous support for the researchers through the research design and project implementation process and encouraging networking and social learning.

Transdisciplinary research is a challenge requiring time, resources and an agreement to disagree in an environment of cooperation and support. Time is needed to work together in such a team to interpret the data collected.

It is also apparent that successfully applying ecohealth requires a long-term horizon. As most projects indicate, the first phase (between 2-3 years) is usually spent on capacity development and on mobilizing stakeholders and conducting base line work, which often sets out the project in different directions, followed by the testing out and assessing of interventions and evaluation of the overall effort, and seeking opportunities for institutional and policy influence usually in the second and sometimes third phases.

The projects illustrate that the presence or absence of human diseases, while obviously an important indicator of human health, may not often be the best measure of overall human wellbeing. More complex social and environmental determinants of well-being are equally important but much more difficult to study since they are imbedded in the complexity of poverty, malnutrition, powerlessness, and environmental degradation. It is this complexity,

and the many confounding factors that come into play, that these projects have unravelled to show the important contributions of ecosystemic analysis and interventions in improving health and environmental sustainability. It also points to the need for inbuilt robust monitoring and evaluation frameworks that can capture processes and outcomes from such projects.

In closing, it is important to note that inherent to Ecohealth work is a strong commitment to empower people and communities to change and improve their own lives; to explore human and organizational behaviour and the associated relationships they create toward the environment; and to work towards more accountable, responsible, and transparent governance on issues that link health and environment (Ecohealth, 2005). The projects reviewed have individually and collectively contributed to this important goal in various and important ways.

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Annex 1: TORs for Synthesis of Agricultural Transformations Sub-theme

The International Development Research Centre's (IDRC) Ecosystem Approaches to Human Health Program Initiative (Ecohealth) is a global program which is currently supporting a body of research and capacity development activities on a number of themes, including the theme of Agricultural Transformations: Linkages to Human Health and Well-Being.

This body of work seeks to show how complex transformations in agriculture (land use changes, environmental degradation, the increase use of agricultural technologies and inputs as a result of intensification, changes in climate, changing livelihood strategies, and the impact of HIV-AIDS on agricultural production in Africa for example) are affecting human health and well-being and the ecosystems on which they depend in rapidly changing rural contexts.

Using eco-systematic, trans-disciplinary, participatory and socially responsible research approaches including social and gender analysis, Ecohealth's support in this focus area aims to:

- 1) improve global and regional understanding and practical knowledge on the range of social, political, economic and ecological health and well-being impacts linked to agricultural transformations.
- 2) design and implement effective and innovative multi-sector interventions to improve human health and sustainable agriculture and environmental management.
- 3) strengthen the capacity of southern researchers and research institutions to address health, agriculture and environment issues and conduct solid policy-relevant research.
- 4) provide the required scientific evidence for policy action at national, regional and international levels and contribute to more informed policymaking and,
- 5) facilitate regional and global linkages/networking ('communities of practice') among partners engaging in this area of work.

The focus of this support on Agricultural Transformations: Linkages to Human Health and Well-Being has been centered fundamentally around three main sub-themes, 1. Environmental contamination, 2. Communicable diseases 3. Access to natural resources for food, nutrition and with a fourth major sub-theme recently developing on 4. Health and adaptation to climate change.

The Ecohealth team is seeking the assistance of an expert consultant, familiar with this field of participatory, transdisciplinary, socially responsible action research and capacity development activities as well as the global context to assist IDRC by reviewing work conducted under this subtheme, extracting and synthesizing salient findings, learning and impacts of this work.. The results of this work will ultimately feed into overall improved and consolidated team learning, better preparedness for the external evaluation of the Ecohealth PI as well as contribute to the documents and preparations for the Ecohealth Forum to be held in Mexico in December 2008.

Fundamentally, the work is expected to show whether and how this subtheme has met its objectives, namely: where/ how/what Ecohealth contributions (at the project level) have

provided new information and improved understanding on the relationships between health and the environment in changing contexts, what interventions were generated and policy influence were realized to improve on human health and contribute to the sustainability of ecosystems, what/whose capacities were built, where and how networks were created and sustained to improve human health and sustainable environmental management.

Annex 2: List of projects and implementing institutions

1. Human Health and Changes in Potato Production Technology in the Highland Ecuadorian Agro-Ecosystem (Phase 1, Bridging Phase, Phase II)- International Potato Center (CIP)
2. Health Risk Analysis of Cryptosporidiosis in Urban Smallholder Dairy Production, Dagoretti, Nairobi, Kenya- Department of Public health Pharmacology and Toxicology, University of Nairobi
3. Development of Health Interventions for El-Fayoum, Egypt: A Holistic Agro-Ecosystem Approach (Phase I and Phase II)-
4. Floriculture Ecosystem Disrupture And Human Health Impact In Cayambe: Participatory Approaches For A Health Ecosystem (Phase I, Bridging phase- dissemination)
5. Land-use Transition and Human Health in the Eastern Himalayas- Pilot phase, phase I- ICIMOD
6. Integrating Malaria Control Interventions with Development Strategies in Kenya- Phase I and II – IWMI
7. Health impact assessment of small dams in Africa: formulating recommendations for better management and increased well being of the local communities. Phase I Morocco – methodology development and community mobilization- Institut National de Recherche Agronomique
8. Health and Dietary Diversity in Yemen (Phase I)- Sana'a University