京都大学防災研究所年報 第 55 号 B 平成 24 年 6 月
Annuals of Disas. Prev. Res. Inst., Kyoto Univ., No. 55 B, 2012

Linking Ecological Risks to Human Health in a Changing Environment: A Brief Introduction of the EcoHealth Research Project in the Philippines

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Synopsis

EcoHealth is an innovative and effective way to generate new knowledge to better address the trade-offs between livelihoods, environment, and human health. It is reported that long-standing environmental hazards, environmental changes, and rapid economic growth are affecting the health and livelihoods of poor people around the world. These vulnerable communities live in degraded ecosystems that threaten their health. With few resources to face these problems, they get exposed to environmental pollution, and new and old infectious diseases. This research aims to link environmental risks to health. More specifically, this study aims at identifying and analyzing the nature of current land use, water and sediment related risks to the health status, with focus on soil-transmitted helminth infections, of the people in selected sites in the Laguna region, Philippines. In the long run, outputs from this study can help suggesting practical policy recommendations to improve current land use and development planning as well as public health systems, while enhancing mutual international level research collaborations between researchers from Japan and the Philippines. The current paper is an introduction of the research project and gives some snapshots of preliminary results.

Keywords: environmental hazards, ecohealth, landuse change, laguna

1. Introduction

Increasing worldwide contamination of freshwater systems with thousands of industrial and natural chemical compounds is one big environmental challenge to humans. Agricultural activities, including intensive livestock production, are often criticized for producing environmental pollution (Schwarzenbach et al., 2006; He et al., 2009, 2011). Especially, in Asian Subtropical areas, water pollution problems have great impacts on human health. Thus, it is necessary to take appropriate measures for sustainable industrial development and agricultural production so they can be in harmony with the environment, preserving and improving the natural cyclical functions.

This study, funded by JST (Japan Science and Technology Agency) called Feasibility Study (FS)

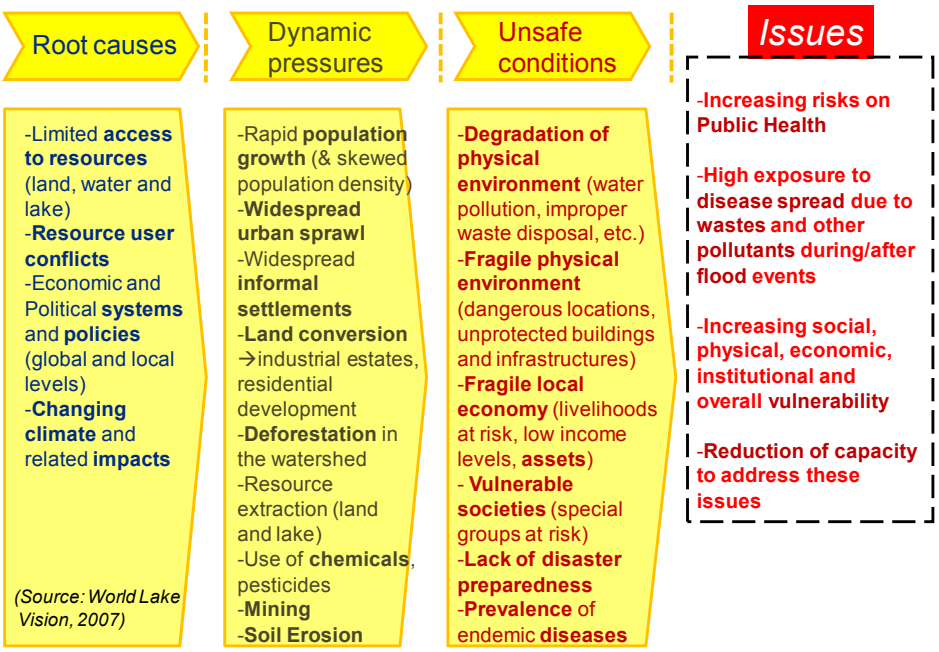

Fig.1 Root causes and dynamic pressures resulting to unsafe conditions and alarming issues in the study area of Lake Laguna watershed.

Young Researchers Satreps EcoHealth project, aims at developing a methodology to better address the inextricable links between human health and the biophysical, social, and economic environments. The funding and implementation of the research took place from November 2011 to March 2012. This feasibility study research project is intended to identify local issues and set up institutional collaborations to be able to solve current issues in the Philippines while mutually reinforcing each counterpart researchers' capacity and knowledge and jointly develop a future research project after the Feasibility Study period.

Placing human beings at the center, the EcoHealth approach aims to achieve lasting improvements in human health by maintaining or improving the environment (IDRC, 2003). Therefore, the challenge of the Ecosystem approach to human health is how to meet human needs without modifying or jeopardizing the ecosystem in the long term, and ideally, even improving it (ibid.). EcoHealth is an innovative and effective way to generate new knowledge to better address the trade-offs between livelihoods, environment, and human health. It is reported that long-standing environmental hazards, environmental changes, and rapid economic growth are affecting the health and livelihoods of poor people around the world. These vulnerable communities live in degraded ecosystems that threaten their health. With few resources to face these problems, they get exposed to environmental pollution and new and old infectious diseases (ibid.).

This FS Project focuses on establishing the interface between human health and ecological risks resulting from environmental degradation. This research considers anthropological causes of environmental degradation such as land use change, urban expansion, and inefficient waste management. Focusing on specific health issues (e.g. Soil-transmitted helminth hereafter referred to as STH infections); the team would try to track environmental conditions contributing to increased risks to infections. The study site is Barangay Marinig in the Municipality of Cabuyao (currently applying for cityhood), a microwatershed inside the Laguna Lake Basin. This barangay is also the site of Southville, a low-cost housing facility of the National Housing Authority, for the relocation of informal settlers from Manila. The selection of

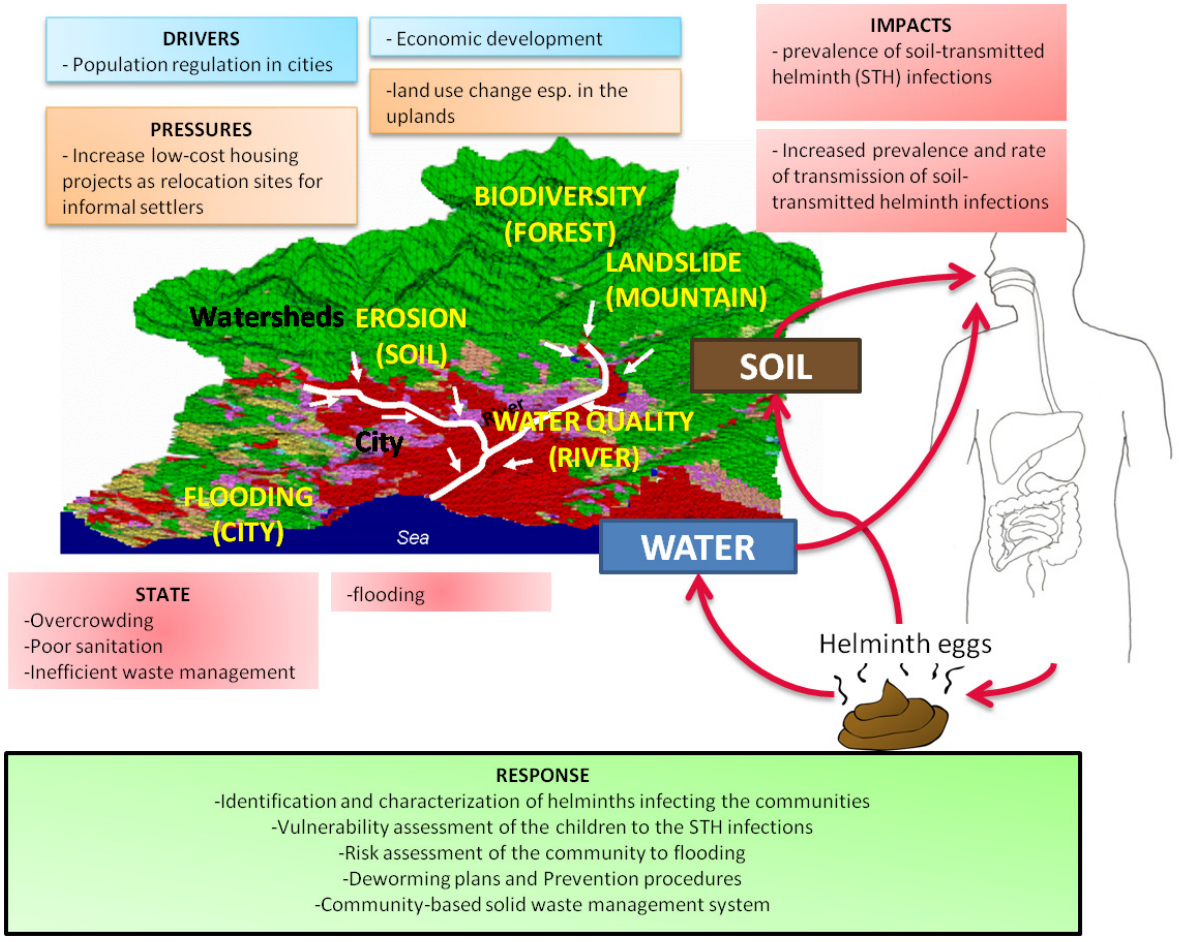

Fig.2 Links between Environmental risks and STH infections.

Barangay Marinig as the study site is based on the expressed concern of local health authorities on the increasing incidence of parasitic helminthic infections among school-aged children despite mass drug administration (MDA) against parasitic worms. There have also been very few studies in the Laguna Lake area that involved one of the neglected tropical infections (in this case, the soil-transmitted helminth infections).

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2. Problem Description

There has been an observed increase in the prevalence of STH infections in the area and the cause of this increase has not yet been investigated. STH infections are most prevalent in developing countries and are usually associated with increased morbidity and mortality. The increased incidence of STH in developing countries can be linked to poverty, inadequate sanitation facilities, unsafe water supply, indiscriminate defecation and poor eating habits (Ulukanligil & Seyrek, 2004). The World Health Organization (WHO) reports that STH infections are the most common of the neglected tropical diseases (NTD), which affects approximately 2 billion people worldwide (WHO, 2008). Children infected with STH usually manifest with stunted growth, decreased physical activity and poor physical and mental development (Easton, 1999). Moreover, chronic STH infections result in loss of appetite, stunting and anemia (Crompton & Nesheim, 2002).

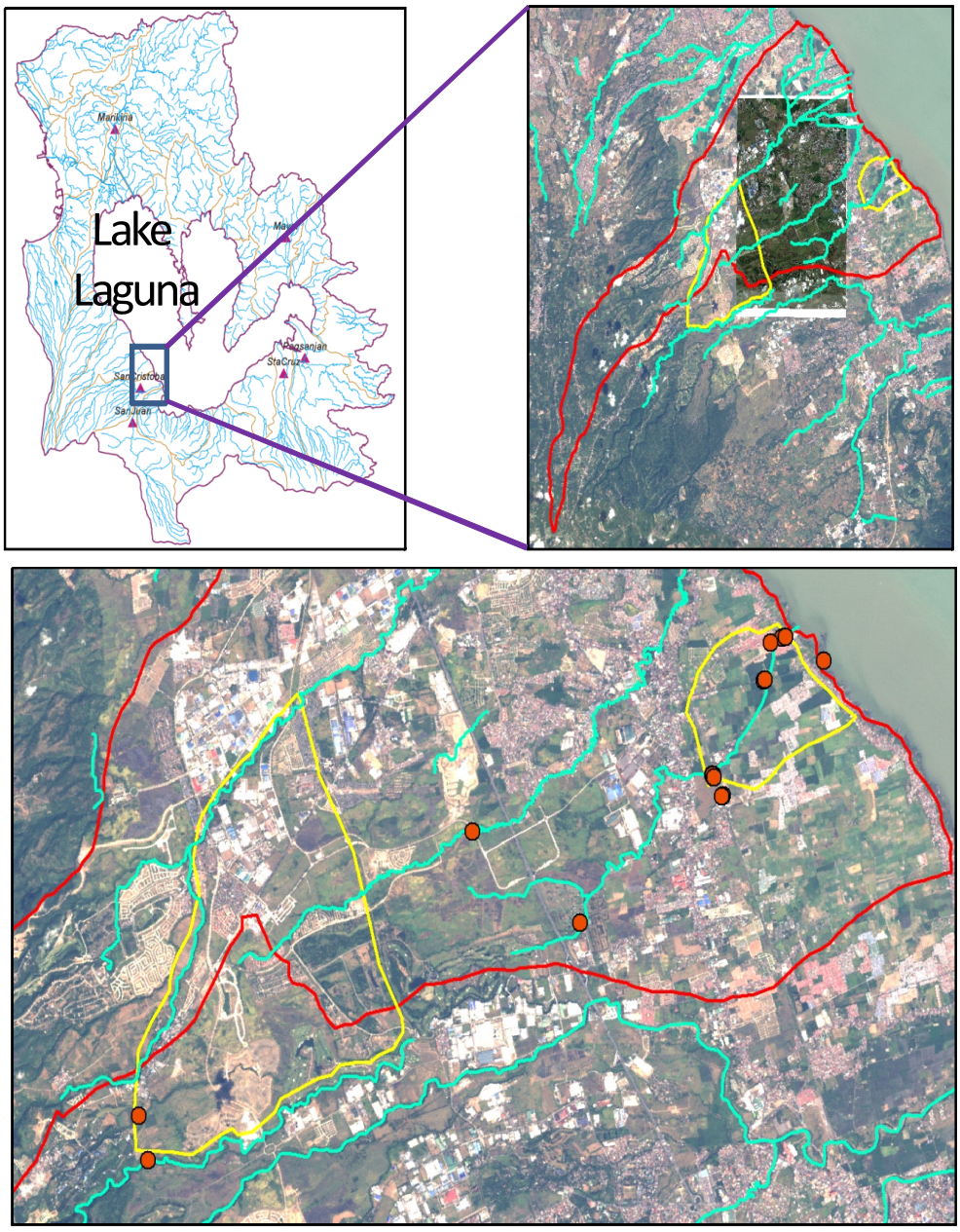

Fig.3 Data monitoring sties in the study area

The area is also frequently flooded since it is located near the lakeshore. However, further evidences are necessary to state that frequent flooding could increase the rate at which the infections are being transmitted. The relationship between the changing landscape in the uplands and the frequency of flooding and prevalence of the infections has not been confirmed. Figure 1 suggests the probable root causes and dynamic pressures that could have led to unsafe conditions and alarming issues in the area

3. Methodology

This transdisciplinary EcoHealth research is conducted in an innovative way by combining medical, natural, environmental, and social sciences and come up with a comprehensive methodology clarifying the link between environmental degradation and people's health. More specifically, this study aims at identifying and analyzing the nature of current land use system, water and sediment related risks to the health security of the people in selected sites in the Laguna region,

Philippines. In the long run, outcomes from such study is intended to suggest practical policy recommendations to improve current land use and development planning as well as public health systems.

3.1 Conceptual Framework

Figure 2 shows the conceptual framework of the study, linking environmental conditions to the pathway of the STH infection in the pilot area.

3.2 Data Collection and Analysis

In brief, data collection was based on literature review, questionnaire survey, interviews and focus group discussions (FGDs), and transects. Data analysis is conducted using statistical (SPSS Package) and geographical information system tools.

The investigation is mainly focused on the following components, although only parts of those are presented in the current paper:

- Characterization of river systems as well as plants and diversity analyses in the selected areas
- Identification and characterization of the helminths causing the infection
- Vulnerability assessment of school-aged children in the community to the STH infections
- Water and sediment-related issues and related community resilience
- Solid waste generation analysis.

3.3 Study site characteristics

The current study is conducted in the Barangay Marinig in the Municipality of Cabuyao, Laguna and Barangay Santo Domingo in the City of Santa Rosa, Laguna. Both areas belong to the Santa Rosa sub-watershed area (Fig 3). The study sites were chosen based on their relative locations in the sub-watershed area; Santo Domingo is a midstream barangay while Marinig is an downstream barangay . Niyugan River Subwatershed is located within Cabuyao City, which is at the northern part of the Laguna province, 45 km away from Manila. Cabuyao City has 18 barangays, 13 of which are part of the Niyugan River subwatershed (including Marinig). The Niyugan River subwatershed has the same geophysical characteristics as Cabuyao City.

The climate in Cabuyao has two pronounced seasons, dry from December to May and wet from June to November. Typically, the maximum rain periods are observed from June to September. An annual mean rainfall of 2000 millimeters is recorded in this city. Cabuyao has general climatic conditions with annual mean temperature of 27.5ºC and annual mean relative humidity of 76%. The annual total rainfall is 1,951 mm during the 171 rainy days recorded per year. The maximum (329.7mm) and minimum (21.5 mm) rainfall occurs in October and February respectively. August has an average of 18 rainy days per month. Rainy season starts in May lasting through November (Cabuyao City CLUP 2010).

4. Preliminary Results

Soil-transmitted helminth (STH) infections remain as one of the major public health problems in the Philippines. Patterns of the occurrence of STH infections are closely linked with several determinants, most notably water quality, sanitation and hygiene in the community.

4.1 The Epidemiology of Soil-Transmitted Helminth (STH) Infections

Stool samples from 393 school children (179 from Marinig [a downstream village] and 214 from Santo Domingo [a midstream village]) were analysed for STH using the Kato-Katz technique. Results of the parasitologic assessment showed an over-all cumulative prevalence of 37.4%. Specifically, 36.9% of school children in Marinig and 37.9% of school children in Santo Domingo were determined to have STH infections though the prevalence proportions of STH infections are not significantly different (p value = 0.8396). The most common soil-transmitted helminth among school children who tested positive for infections is *Trichuris trichiura* (26.0%) followed by *Ascaris lumbricoides* (24.2%). None of the school children tested positive for hookworm infection. The same pattern of specie-specific infection rates can be observed for both study areas. There also appears to be no significant difference in specie-specific prevalence rates between Santo Domingo and

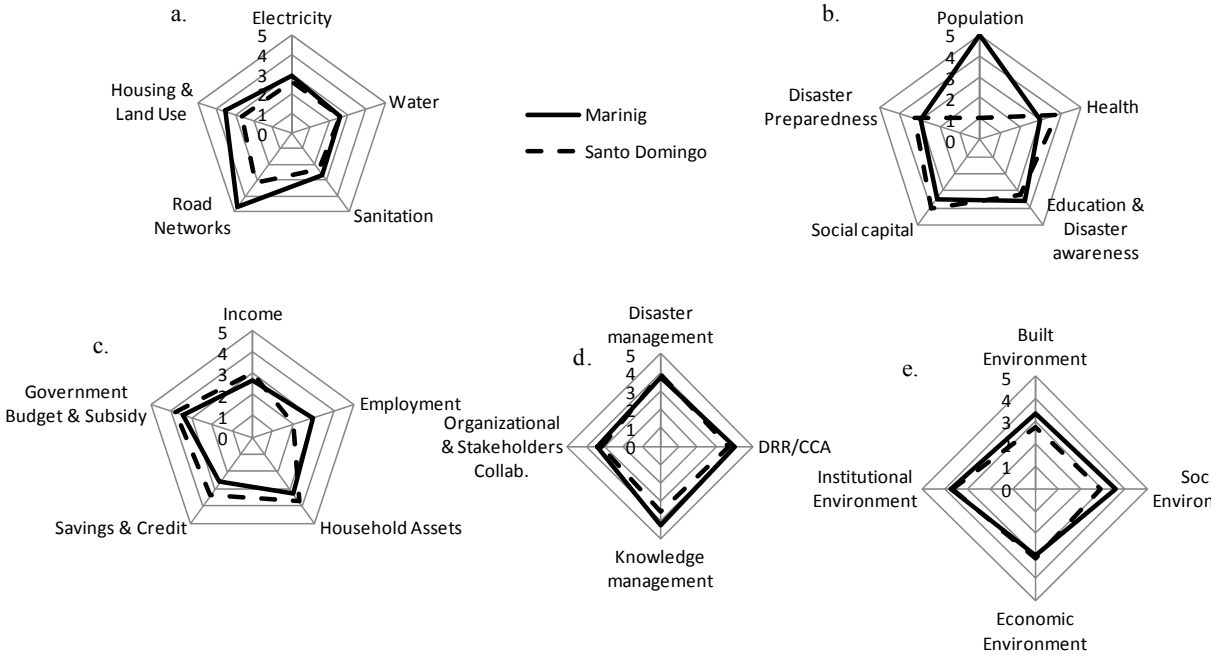

Fig.4 Results of resilience level to flooding in the two studied locations (Barangay Marinig and Santo Domingo), specific resilience level include the resilience of Built Environment (a), Social Environment (b), Economic Environment (c) and Institutional Environment (d); e. summarizes the overall Resilience index of the two selected areas

Marinig.

However, the prevalence of heavy intensity *Trichuris* infection is significantly higher in a downstream village (8.4%) compared to a midstream village, (3.4%). Moreover, geometric mean egg counts for *Ascaris lumbricoides* (9.0 eggs per gram) and *Trichuris trichiura* (3.8 eggs per gram) are significantly higher in the downstream village compared to a midstream village (5.2 eggs per gram for *A. lumbricoides* and 3.2 eggs per gram for *T. trichiura*).

The results of the study may provide estimates on the prevalence of STH infections among school children in each of the barangays. However due to limitations in the methodology, the generalizability of the prevalence measure must be also be interpreted in the context of the proportion of children actually enrolled in the elementary schools. Infection rates obtained from this study may also not be reflective of STH infection prevalence in the provincial or regional level.

Although a great majority of the STH infections are classified as mild intensity, it should be noted that even mild intensity infections can have significant clinical consequences in certain individuals if left inadequately treated or untreated altogether, most notably in those who are undernourished or in those with co-morbidities. On the other hand, the predominance of light intensity infection may signify the effectiveness of current drug treatment or indicate that the risk for autoinfection and super-infection is low.

Though the cumulative prevalence and specie-specific prevalence proportions are not significantly different between the study sites, the prevalence of heavy intensity *Trichuris* infection and the geometric mean egg counts of *Ascaris* and *Trichuris* are significantly higher in school children from a downstream barangay compared to children from a midstream barangay. Though it is beyond the scope of this study to establish environmental determinants of STH infections, the geospatial distribution of STH infections seem to indicate that lower typographic elevations, quaternary alluvium geologic formation and an rural to urban transition of land use may play a role in the magnitude of STH infection and worm burden.

Hence, since STH infections fit the traditional

host-agent-environment triad of disease transmission, elimination of STH infections do not rely solely on treatment of the host. In a study by Belizario et. al. in 2005, even a 95.3% coverage of mass drug administration against helminthic infections only resulted in a reduction of STH prevalence by 30.6%. This implies that further reduction in STH prevalence can only be attained by promoting and ensuring environmental sanitation in addition to improving access to essential health services, among others. Reinfection rates among children previously treated for the infection will certainly be persistently high if they are exposed to the same behaviours, practices and environment that made them susceptible to infections in the first place.

4.2 Solid Waste, Sanitation and Soil Transmitted Helminths (STH)

Soil transmitted helminthiasis (STH) persist in the Philippines where poverty, inadequate sanitary facilities, indiscriminate defecation, poor eating habits, and ignorance of unhealthy behaviors predominate (MVP/WPRO, 2008). Results from the survey reveal that 51% of respondents have experienced deworming their school-aged children 2-3 times in the past 2 years.

One factor that may have contributed to STH incidences is poor solid waste management of households. As major developments of helminths occur in the soil, factors such as temperature and humidity might have determined its distribution. Indiscriminate dumping of waste on ground may have contributed to the level of moisture and temperature in the soil that promotes helminth occurrences.

Another factor is inadequate sanitation facilities and practices. The study shows that residents have own sanitation facilities where 88% of respondents have toilet with own septic tank inside their houses and only 12% have toilet outside their homes. Although, the value is high, another factor that may have contributed to incidence of STH infection is the habit of washing hands without using soap before eating (86%). According to Centers for Disease Control and Prevention, washing hands with soap is the most effective way to prevent the spread of infectious diseases.

Using household survey data, a simulation model was developed through Stella modeling software. The model simulated a number of scenarios that would predict waste generation of households in a span of five years. Scenarios include the adoption of interventions like recycling, reuse and presence of a Materials Recovery Facility (MFR).

4.3 Plant species identification and diversity analyses

Aside from species identification, species richness and abundance of species within plots were also determined as an input for the diversity analyses. Using BdPro98, Simpson and Shannon-Weiner diversity indices were computed and the plots were compared based on similarities using the Bray-Curtis Single-Link analysis in the program.

Moreover, the identified species were used to assess the adequacy of physiological factors for plant growth and development. Similarly, the indices generated were used to substantiate the capacity of the identified sites to sustain different species. Abundance of the species was used to determine the extent of dominance and over-dominance of a species given the set of physiographic factors with various precedent land-uses.

Results showed that different land use systems found at different elevations had contributed to the differences in the diversity of the species found within areas with precedent land-uses. In addition elevation as a physiographic factor had substantially affected the physiognomic identities of the different sites following the alterations of precedent land-uses to existent cover. The study also was able to analyze the extent at which precedent land-uses can enhance cover and how land-uses are able to create suitable environments for favored species. However, it is important to incorporate solid hydrological data, namely the capacity of species to intercept rainfall and effects of species diversity to surface run-off and erosion, to further characterize the physiognomic factors present in the river system for more intricate management recommendations.

Table 1 Helminth egg analysis results

			Eggs per gram		
Site	**Latitude**	**Longitude**	**Roundworm (Toxocara sp.)**	**Whipworm (Trichuris sp.)**	**Hookworm (Ancylostoma sp.)**
JST13B	14.24385	121.10652	0	0	0
JST14B	14.24799	121.11317	2	2	0
JST15	14.25064	121.10330	1	1	0
JST16B	14.26308	121.13334	17	19	0
JST17B	14.26611	121.13227	4	6	0
JST18B	14.27824	121.13998	1	0	0
JST19B	14.27443	121.14223	1	1	0
JST20B	14.28385	121.14348	0	0	0
JST21B	14.28266	121.14065	0	0	0
JST22B	14.26568	121.12679	1	1	0

4.4. Community Resilience to Flooding

According to the results of resilience surveys in Marinig and santo Domingo, a slightly higher overall resilience index was found at Marinig (Fig. 4). The same Barangay scored higher as well on specific resilience, namely on Built Environment and Institutional Environment. In Santo Domingo, disaster preparedness as well as health factors were found higher despite a higher number of people living in informal settlements.

The barangay performs well in term of budget and savings/credits but scores less in employment opportunity. Water and sanitation almost had a similar trend for the two areas with less resilience levels in comparison to other factors.

4.5 Vulnerability assessment of school-aged children in Marinig, Laguna,

A vulnerability index of the school-age children to the Soil Transmitted Helminth (STH) infections was developed based from the risk factors to the infection (as given by the Centers for Disease Control and Prevention) and environmental quality and other physical factors of the study area. The overall index of vulnerability was computed using the formula: *Vulnerability (V) = (Sensitivity (S) + Exposure (E))/Adaptive Capacity (AC)*. Sensitivity factors were identified from previous studies focusing on STH infections: presence of TV and radio, type of toilet, presence of septic tanks, water resource, animals in the house, place of cooking, soap use/hygiene practices, and waste management. Sensitivity factors were assumed to be the risk factors within the immediate environment of the respondents. These sensitivity factors were ranked according to their perceived contribution to the risk of acquiring STH infections. Proportion of the population having the specific characteristics was determined and multiplied to factor weights. Weights were derived from the average ranks by scaling them to a range of 0.0 to 0.8 (not 1.0, since the ranks are computed from expert opinions): $SF = (RF_1 * w_1) + (RF_2 * w_2) + \ldots (RF_n * w_n)$, where SF = Sensitivity Factors, RF_1 = proportion of the population possessing a risk factor, w_1 = weight associated with sensitivity factor 1. Exposure factors were assumed to be the environmental factors in the community that are hypothesized to have contribution in acquiring STH infections: river health and the number of helminth eggs in the soil. Adaptive capacity was assumed to be the preventive and reactive responses against STH infections: policies, vaccination campaigns, and health programs. The overall index was interpreted using a scale from 0.00 to 1.00; 1 indicating highest vulnerability. The index can be used by the barangay to strategize plans on the reduction of STH infections and campaigns on river rehabilitation and environmental sanitation.

The vulnerability index of the school-aged children to STH infections was found to be 'high' (having a value of 0.83). This value resulted from a

high exposure score because of deteriorating river health and the presence of helminth eggs in the river banks. These conditions were hypothesized to be caused by the absence of solid waste management system and a sewage treatment facility in the area. If Barangay Marinig would like to lessen the incidences of helminth infections, it would be best to consider the development and implementation of a solid waste management plan and a sewage treatment facility.

5. Conclusion

This paper focusing on the interlinkage between environmental risks and human health is an overview of currently ongoing studies. Thus, rather than a full description of outcomes in this study, this manuscript is considered to be a snapshot of current initiatives and further results will be discussed and published in peer-reviewed journals.

As the organisms leading to Soil-Transmitted Helminth Infections have a life cycle that occurs in soil, and the human host being exposed to those (the disease is transmitted through the fecal-oral or dermal route), further investigations need to be conducted to determine environmental factors that favor the transmission of disease. Lacking in this investigation, more in-depth studies on how land use pattern is changing in the face of rapid urbanization, economic growth and related disparities are necessary. Another missing link that was not clarified in this study is the change of STH infections as affected by water related issues such as floods and river pollution. Such studies are both timely and relevant as ecological changes, mainly as results of human activities as well as climate variability, may modify the drivers and patterns of transmission not only for this type of infection but for many other sources of human morbidity and mortality. More analyses should be done to clearly show the interlinkage between environmental conditions, related impacts to people's health, lives and livelihoods, the foundation of our Ecohealth approach.

Acknowledgements

The authors address their deep thanks to JST (Japan Science and Technology Agency) Feasibility Study Satreps Young Researchers Project which funded the study (FS Project #027). Special thanks also go to the Food and Heath Risk (Lakehead) Project at the Research Institute for Humanity and Nature, and the Disaster Prevention Research Institute, Kyoto, Japan for their advices and supports. We do not forget to thank Philippine local government and health officers for their supports during the investigations.

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変化する環境での生態リスクと健康を結ぶ研究：エコヘルスアプローチ

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要　旨

EcoHealth とは，人々の暮らしや環境と，人間の健康との間の代替関係を効果的に扱うための新しい知識を生み出す，革新的かつ効果的な研究アプローチである。世界各地において，長期的な環境の危機や環境変化，高度経済成長が，貧しい人々の健康と暮らしに悪影響を与えていることが指摘されている。多くの脆弱な共同体では，人々が健康を脅かされる劣化した生態系に住んでいることが多く，環境汚染や新旧の伝染病の危険に直面している。そこでこのEcoHealth 研究プロジェクトでは，生態リスクと人間の健康との関係のつながりを明らかにし，熱帯地域における健康問題をより効果的に扱うための方法論を開発することを目的としている。具体的には，フィリピンラグナ地域を研究対象として，過去から現在への土地利用変化の性質と程度，水質や堆積物汚染に関連したリスクが人々の健康へ与える影響を分析し，問題点を明らかにする。さらにこのEcoHealth アプローチでは，人間の健康の永続的な改善を目的とした，土地利用や公衆衛生制度の向上に貢献する実用的な政策提言を行うとともに，本研究を通して，日本とフィリピンの研究者相互の国際的な共同研究能力を向上させることを目指す。

キーワード：生態リスク，エコヘルス，土地利用変化，ラグナ湖，フィリピン