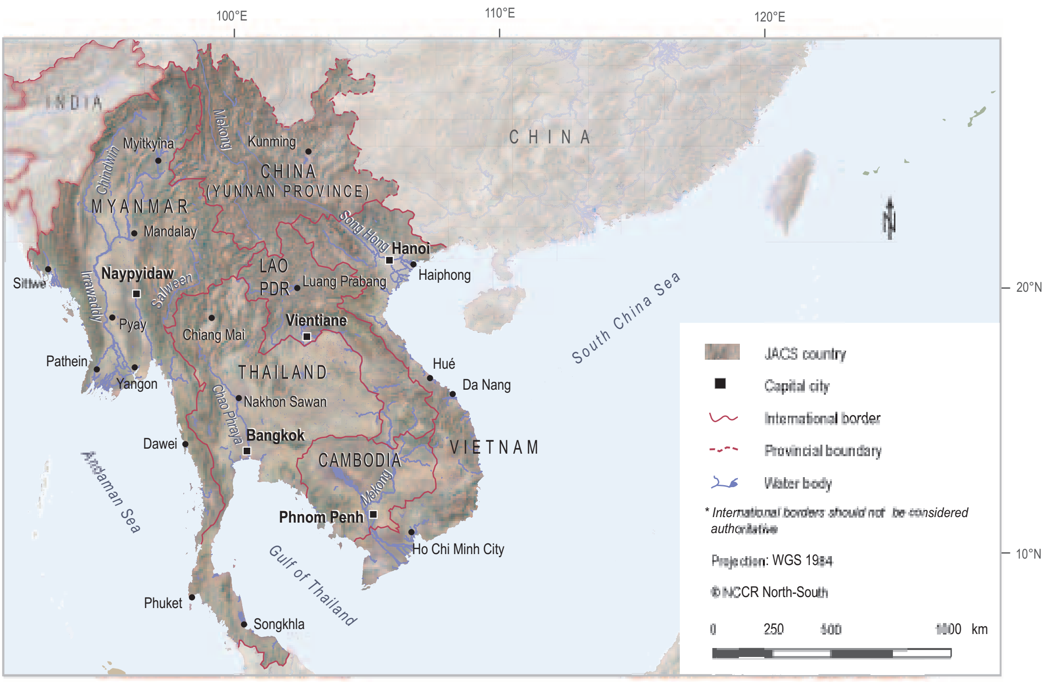
Part VI

Integrated Approaches to Environmental Management in Southeast Asia



21 Dealing with Sanitation, Environmental Dynamics and Disparities: Research Partnerships in Southeast Asia

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21.1 Background

Among the world's fast-growing regions, the so-called Greater Mekong Sub-region (GMS) in Southeast Asia is one of the richest in terms of variety and quality of natural and environmental resources (Figure 1). The GMS includes Cambodia, Lao PDR, Myanmar, Thailand, Vietnam, and Yunnan Province in China. It has a total population of 240 million people and covers some 2.3 million km^2. In recent decades, the rapid economic growth of the GMS countries has increased disparities in terms of wealth and access to natural resources among their rapidly growing populations. Economic growth has also placed tremendous pressure on the region's natural resources and the environment. Problems such as deforestation, soil degradation, inadequate environmental sanitation services and pollution of water resources have become more serious and have been recognised by national and local authorities as an important area for action.

The countries in the GMS, with the support of international development cooperation, have put tremendous efforts into sustainable development, poverty alleviation, minimisation of disparities in resource distribution, managing natural resources, and protecting the natural environment. A number of national and international institutions involved in minimising environmental problems and building a well-managed society have, nonetheless, been constricted and impeded by numerous obstacles (Hurni et al 2004), among which the most critical are:

- Policy and regulatory frameworks that do not enable or support integration of environmental and economic planning;
- Centralised decision-making related to public services, infrastructure and the natural environment;

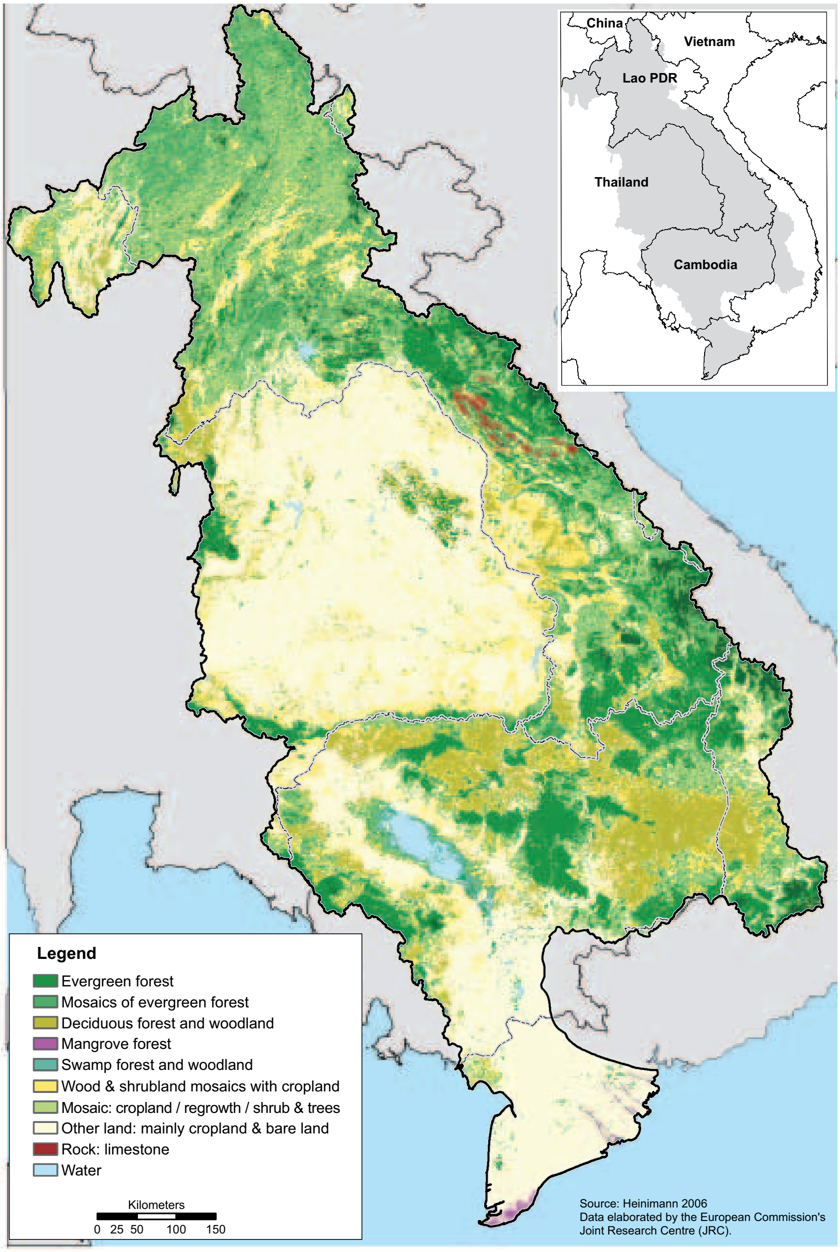

Fig. 1
Major land-cover categories in the lower Greater Mekong Sub-region (GMS) countries. (Source: Heinimann 2006)

Fig. 2
Hanoi and other Southeast Asian cities have rapidly grown in an uncontrolled manner, leading to major environmental problems. (Photo by Antoine Morel, 2008)

– Inadequate databases and funding to support participatory decision-making; and
– Ineffective design, enforcement and monitoring of policy implementation.

For instance, access to adequate environmental sanitation services is recognised as a priority issue for socio-economic development in most developing countries (Millennium Development Goal 10). While many sanitation programmes have been implemented in recent years, interventions in this sector often focused on strategically important areas, including high-income areas, rapidly growing urban centres, or touristic zones. Fast-growing city centres such as Luangprabang and Vientiane (Lao PDR), Bangkok (Thailand), Hanoi (Vietnam) and Kunming (China) applied a conventional approach to provision of environmental sanitation services (i.e. 'flush and forget'; Figure 2); however, the problems are often redirected downstream to more vulnerable areas of less economic importance, resulting in increased environmental degradation and health threats (Kamal et al 2008). These typical practices have led to increased socio-economic and environmental disparities within urban communities, especially in Southeast Asia, where urbanisation rates are among the highest in the world.

Core problems of unsustainable development in Southeast Asia are not limited to the urban and peri-urban context. One other core issue is the poor management of natural resources in high- and lowland rural areas where the great majority of people rely on subsistence or semi-subsistence agriculture. Even in Vietnam, with average GDP growth rates of 10% per annum over the last decade, economic development still depends heavily on agricultural production. Such rapid development means that countries have to deal with enormous changes; emerging markets and new business opportunities typically increase the risk of spatially overlapping and conflicting interests in natural resources (Thanh Be et al 2007). While traditional subsistence agriculture depends on various forest products for domestic and local consumption, intensively cultivated farmlands likely utilise the same productive areas for larger-scale resource use.

Focusing on the above-mentioned regional problems, researchers of the Swiss National Centre of Competence in Research (NCCR) North-South in Southeast Asia have jointly undertaken field research with the ultimate aim of determining integrated management approaches to deal with environmental dynamics and disparities in both urban and peri-urban as well as highland–lowland contexts. These integrated approaches should enable key actors or stakeholders to effectively employ interventions that are appropriate for handling sustainable management and utilisation of natural and environmental resources with minimal adverse impacts on people's livelihoods. NCCR North-South research activities in Southeast Asia have thus emphasised three overarching research themes: (1) equity-effective and environmentally sustainable sanitation for reducing disease burden (health risks); (2) multi-level stakeholder processes for development of interventions and coping strategies; and (3) livelihood and environment in trans-contextual perspectives.

Eight years into the NCCR North-South research and capacity development programme, it is crucial to assess the achievements of activities in the region by synthesising the research outputs relating to the aforementioned research themes. Three relevant synthesis themes have been consolidated and highlighted: 1) *Potential and Limitations of Decentralised Wastewater Management*; 2) *Innovative Tools for Environmental Sanitation Planning and River Basin Management*; 3) *Accessibility as a Determinant of Environmental Dynamics and Socio-economic Disparities.*

21.2 Attempts to develop integrated management approaches

Since 2002, field research activities in the NCCR North-South's Joint Area of Case Studies (JACS)[2] Southeast Asia (SEA) have been jointly developed and undertaken by researchers from both the North (Switzerland)[3] and the South (Thailand, Vietnam, Lao PDR and China), with their respective local and regional partner institutions (Table 1). A research partnership network was established, involving around 40 researchers – 2 post-doctoral researchers, 10 PhD candidates, 7 senior researchers, 6 research associates, and 15 Master's students. This partnership network was able to conduct high-qual-

Table 1

Partner institutions of the Swiss National Centre of Competence in Research (NCCR) North-South's Joint Area of Case Studies (JACS) Southeast Asia (SEA).

Country	Partner institutions
Thailand	School of Environment, Resources and Development (SERD), Asian Institute of Technology (AIT)
	Pollution Control Department (PCD), Ministry of Science, Technology and Environment
	Mahidol University (MU)
	Faculty of Environment and Resource Studies, Thammasat University
	Southeast Asian Ministers of Education Organisation–Regional Centre for Archaeology and Fine Arts (SPAFA)
Vietnam	Hanoi University of Civil Engineering (HUCE)
	National Institute of Soil and Fertiliser (NISF)
	National Institute of Hygiene and Epidemiology (NIHE)
	Urban Rural Solutions (URS)
	AIT Centre Vietnam (AIT CV)
Lao PDR	Lao National Mekong Commission Secretariat (LNMCS)
	Urban Research Institute (URI)
	Swiss Agency for Development and Cooperation (SDC) Lao PDR
Cambodia	Royal University of Phnom Penh (RUPP)
China	Kunming Institute of Environmental Science (KIES)
	Yunnan Academy of Social Science (YASS)
	City Government of Kunming, Kunming, People's Republic of China
	Department for Environmental Science and Engineering, Kunming University of Technology

ity research, as evidenced by the number of scientific publications and other research outputs, some of which have been transferred into practice by local partner institutions or integrated into national policies.

Field research related to the first two themes, *Potential and Limitations of Decentralised Wastewater Management* and *Innovative Tools for Environmental Sanitation Planning and River Basin Management*, was conducted within the framework of the Household-Centred Environmental Sanitation (HCES) approach. The HCES approach is a demand-responsive, participatory and community-focused approach for improving environmental sanitation services, and relies on the availability of appropriate sanitation technologies as well as supporting tools for informed decision-making. Research therefore first focused on the development of appropriate environmental sanitation systems, with an emphasis on decentralised wastewater management. In laboratory and pilot-scale experiments, wastewater treatment systems were investigated in terms of treatment efficiency, operation and maintenance requirements, compliance with national discharge standards, and costs. The Anaerobic Baffled Reactor (ABR) and Constructed Wetland (CW) systems were experimentally tested because of their high treatment performance, their minimal energy consumption, and their financial competitiveness – all important preconditions for decentralised wastewater management schemes. As a result of the field testing, design and operational criteria for the ABR and CW systems were defined and published in technical manuals. These were then adopted by the environmental authorities in the region (e.g. the Pollution Control Department of Thailand and the Ministry of Construction in Vietnam), which consequently implemented the recommendations and results in several peri-urban communities. Research also focused on the limitations of wider-scale application of such systems. Lack of public acceptance of such innovative technologies, lack of capacity to plan and implement these systems, and hindering policies and regulations were identified as the main limiting factors, as elaborated in Chapter 22 of the present volume.

In addition to the field testing of decentralised wastewater treatment systems, NCCR North-South research included applications of Material Flow Analysis (MFA) to depict obvious environmental pollution and scenarios for its management. Field research activities concerned with MFA were pursued at various scales, from the university campus to the small-scale community and the large-scale municipality, up to the river basin in Thailand, Vietnam and China (Yunnan Province). Recognising the public health threats caused

Fig. 3
A typical hanging latrine over a fish pond in a peri-urban community in Cantho city, Vietnam. (Photo by Thammarat Koottatep)

by poor environmental sanitation services (Figure 3), field research encompassed the study of health risk assessment using the Quantitative Microbial Risk Assessment (QMRA) technique. Though MFA and QMRA provided sufficient analytical information for environmental sanitation planning with respect to environmental pollution and public health threats, an understanding of stakeholders and their vital roles in decision-making and/or implementation processes was also required. Researchers thus developed and tested a set of systematic tools for stakeholder analysis that enables and enhances stakeholder involvement in effective participatory planning. Applications of these tools are well documented and explained by selected case studies in Chapter 23 of the present volume.

Research on the third theme, *Accessibility as a Determinant of Environmental Dynamics and Socio-economic Disparities*, addressed environmental dynamics in the highland–lowland context and was designed to provide spatially explicit meso-scale information on development disparities and the status and dynamics of natural resources. Research on the geography of welfare in Vietnam demonstrated that poverty and inequality maps may be misinterpreted if spatial patterns specific to important sub-populations remain unclear. In the environmental realm, land-cover research in the lower

Mekong basin showed the distinct scars that various long-term land-cover change processes – related to the level of market integration and depending on the political context – left on the landscape in the riparian countries of the lower Mekong basin. Based on insights of great interest from these studies that showed clear patterns of poverty and environmental characteristics (see Chapter 24 in the present volume), very recent research has been oriented towards integrated analysis of the poverty–environment nexus in Laos, with the aim of detecting typical patterns of environmental degradation and related welfare or poverty, and vice versa.

In addition to the aforementioned research activities, NCCR North-South researchers and their local partners jointly implemented Partnership Actions for Mitigating Syndromes (PAMS), a programme component designed to transfer the knowledge gained from research but also to test the applicability of research results.[4] Altogether, six PAMS projects were implemented in the Joint Area of Case Studies (JACS) Southeast Asia (SEA) (Table 2),

Table 2

PAMS	Duration	Location	Main outcomes
Woman negotiating the borders: Marketing route and cross-border trade of inland fish between Thailand and Cambodia	2003–2004	Cambodia and Thailand	Implementation of gender-sensitive policy for border trade
Implementation, monitoring and promotion of urine-separating dry toilets in a village in China	2003–2004	Kunming, China	Acceptance of urine-separating toilets in peri-urban communities
Developing a socio-economic atlas of Vietnam	2004–2005	Vietnam	Adoption of socio-economic atlas for development planning
Development of technical guidelines on constructed wetlands for septage treatment and management	2004–2005	Thailand	Application of technical guidance as a national code of conduct
Effective sanitation systems through stakeholder involvement: A case study of faecal sludge management in Thailand	2007–2008	Thailand	Adoption of some developed strategies into the national master plan for environmental health and sanitation
Participatory improvement of urban environmental sanitation services in Hatsady Tai, Vientiane, Lao PDR	2008–2009	Lao PDR	Increased awareness and capacity on participatory planning of sanitation improvement facilities

Partnership Actions for Mitigating Syndromes (PAMS) carried out in the Joint Area of Case Studies (JACS) Southeast Asia (SEA) during 2002–2009, and their main outcomes.

all of them dealing with integrated approaches to environmental management. One promising outcome of these PAMS was that the management interventions developed during the PAMS were then translated into policy. For instance, the Department of Health of the Thai Ministry of Public Health adopted the technical guidance and recommended strategies for septage management from two PAMS (SEA-4 and SEA-5) in a national master plan for environmental health and sanitation in 2008 and an updated ministerial decree on faecal sludge management in 2009.

21.3 Outlook and ways forward

Integrated management has proved to be a promising approach for coping with unsustainable patterns of development in fast-growing regions of GMS countries. However, long-term evidence based on transdisciplinary research, and its transfer into actions or policy implications, is still required. In future, NCCR North-South research in Southeast Asia will focus further on the adopted research themes, with several slight adjustments: 1) Multilevel stakeholder processes for development; 2) Sustainable sanitation and health interventions; and 3) Livelihood and environment in trans-contextual perspectives. Integration of sanitation and health risk assessments within the framework of participatory planning, for instance, will be a key area of research. In addition, analysis of the contribution of environmental sanitation interventions to climate change mitigation and to emerging health issues will be included.

Given the existing competences and expertise of the NCCR North-South team in the region, it appears necessary to explore new research partnerships with other institutions when it comes to transdisciplinary research for sustainable development. We anticipate linking NCCR North-South research activities with the Association of Southeast Asian Nations (ASEAN) Regional Center of Excellence on MDGs at the Asian Institute of Technology (AIT), which provides a broad networking platform for research and academic institutions in the region and beyond.

Endnotes

Full citation for this article:
Koottatep T. 2010. Dealing with sanitation, environmental dynamics and disparities: Research partnerships in Southeast Asia. *In:* Hurni H, Wiesmann U, editors; with an international group of co-editors. *Global Change and Sustainable Development: A Synthesis of Regional Experiences from Research Partnerships.* Perspectives of the Swiss National Centre of Competence in Research (NCCR) North-South, University of Bern, Vol. 5. Bern, Switzerland: Geographica Bernensia, pp 331–341.

Acknowledgements:
The author acknowledges support from the Swiss National Centre of Competence in Research (NCCR) North-South: Research Partnerships for Mitigating Syndromes of Global Change, co-funded by the Swiss National Science Foundation (SNSF), the Swiss Agency for Development and Cooperation (SDC), and the participating institutions.

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[2] The NCCR North-South is based on research partnerships with researchers and research institutions in the South and East. These partnership regions are called JACS (Joint Areas of Case Studies). Regional Coordination Offices (RCOs) were established in each of these JACS at the outset of the programme. The original function of the RCOs was to coordinate research; in the third phase of the programme, RCOs will consolidate the existing research network in the South and will become hubs for generating new research projects and partnerships.

[3] Mainly from the Department of Water and Sanitation in Developing Countries of the Swiss Federal Institute of Aquatic Science and Technology (Eawag/Sandec), the Swiss Tropical and Public Health Institute (Swiss TPH), and the Centre for Development and Environment (CDE).

[4] Partnership Actions for Mitigating Syndromes (PAMS) are projects implemented by local actors together with scientific and non-scientific stakeholders. As a component of the NCCR North-South programme they are designed to implement and validate approaches, methods and tools developed in research, with a view to finding promising strategies and potentials for sustainable development. Moreover, they are intended to promote mutual learning and knowledge-sharing between academic and non-academic partners in sustainable development.

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22 Potential and Limitations of Decentralised Wastewater Management in Southeast Asia

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Abstract

In rapidly growing cities of Southeast Asia, decentralised technologies for wastewater treatment have a great potential for mitigating the problems of water pollution and water scarcity. This article synthesises research conducted in Thailand, Vietnam and China with the aim of identifying the potential and limitations of introducing decentralised approaches into domestic wastewater management in the region. Laboratory and pilot-scale research on anaerobic baffled reactors (ABRs) and constructed wetlands (CWs) in Thailand and Vietnam revealed that decentralised wastewater treatment technologies can treat domestic wastewater to satisfactory levels at reasonable costs. While the benefits of a decentralised approach are widely recognised within the international scientific community, very few systems are actually implemented in Southeast Asia. Barriers to wide-scale recognition and application of decentralised systems are manifold. Many policy- and decision-makers do not yet perceive decentralised wastewater management as state-of-the-art, indicating technical limitations and a lack of public acceptance as the main obstacles. This lack of political commitment hinders the creation of enabling institutional and legislative frameworks. A basic lack of capacity to plan, implement and operate systems was also identified as an important barrier to wide-scale application and sustainable management of at-source pollution control measures in Southeast Asia. While the limitations are known, measures to overcome these barriers are far more complex. An enabling environment must be created by raising awareness of the importance of wastewater management and of opportunities such as decentralised approaches, creating supporting policies and regulations, identifying suitable financing mechanisms and incentives, and building capacity to plan, implement, operate and maintain such systems.

Keywords: Pollution control at the source; decentralised wastewater management; anaerobic baffled reactor; constructed wetland; enabling environment; Southeast Asia.

22.1 Introduction

The provision of adequate water and sanitation services is one of the oldest and most fundamental challenges in the urbanising world. Historically, most Western countries have relied on sewer systems with centralised wastewater treatment plants optimised for water pollution control. For a long time, it was generally accepted that this model could be exported to any part of the world. While the conventional approach to urban environmental sanitation has contributed greatly to the improvement of hygienic conditions in industrialised countries that could afford to install and operate these systems, it is now generally recognised that under certain circumstances, this 'end-of-pipe' strategy leads to failure (Larsen and Gujer 2001; Zurbrügg et al 2004). In most cities in Southeast Asia, only a small part of the wastewater collected in sewer lines is treated. In Kunming, China, for example, despite large investments in centralised treatment plants in the last decade, only 25% of wastewater collected in the city sewer system is treated, with most of the untreated remainder entering Dianchi Lake – the main drinking water source of the city – via overflows (Huang et al 2006). It was further simulated that even the application of the best available technology – upgrading of the city's urban wastewater collection and treatment system to up-to-date standards – could not prevent lake eutrophication. Indeed, simulations showed that only a combination of innovative measures could solve this problem.

There is a growing tendency to argue that decentralisation of wastewater management would be more effective than centralised systems. In general terms, decentralisation may be defined as a transfer of the authority, functions, resources and responsibilities of government, management or administration from the national (central) level to 'sub-national levels', including lower levels of government, administrative field offices, the private sector, NGOs representing the community, and the community itself. Decentralisation of wastewater management relates to planning and decision-making, design of physical infrastructure, and management arrangements for operations and maintenance (Parkinson and Tayler 2003). The decentralised approach offers important benefits, namely the possibility of dealing with wastewater locally and applying pollution control measures at the source. By tackling pollution problems close to their source, the large capital investment required for trunk sewers associated with centralised systems can be reduced, thus increasing the affordability of wastewater management systems. In terms of planning, decision-making and management, a decentralised approach makes it possible to devolve responsibility from centralised institutions to lower operational levels, promoting partnerships between community groups, private sector organisations and government agencies. These partnerships increase local accountability, provide greater opportunities for community participation, and can result in a service that is more affordable and responsive to the needs and demands of local stakeholders (Strauss and Montangero 2003).

Despite the above-mentioned opportunities, pollution control measures at the source are not yet fully recognised as an alternative to the conventional centralised wastewater management approach. The present article synthesises the outcomes of a series of research projects conducted within the framework of the Swiss National Centre of Competence in Research (NCCR) North-South programme that aimed to determine the technical potential of promising decentralised wastewater treatment systems and identify the main barriers to their wider implementation in Southeast Asia.

22.2 Methods and approaches

The treatment potential of technologies for domestic wastewater treatment was assessed based on a review of different NCCR North-South related projects. The review focused on the anaerobic baffled reactor (ABR) and constructed wetlands (CWs) for the pre- and post-treatment of domestic wastewater, respectively.

The ABR is a technically modified septic tank, which is the most commonly applied method for on-site treatment of domestic wastewater in Southeast Asia (Nguyen et al 2007). The ABR differs from the conventional septic tank system in that it is operated in an up-flow mode, resulting in both improved physical removal of suspended solids and improved biological conversion of dissolved components (Figure 1). While the ABR was suggested by several researchers as a promising system for the treatment of high-strength industrial wastewater (see Barber and Stuckey 1999 for a comprehensive review), its applicability for the treatment of low-strength domestic wastewater in tropical conditions is not well documented.

The CW is a natural wastewater treatment system that combines multiple treatment modules, including biological, chemical and physical processes (Babatunde et al 2008). The technology has been successfully used for the treatment of a wide variety of wastewaters, including domestic wastewater,

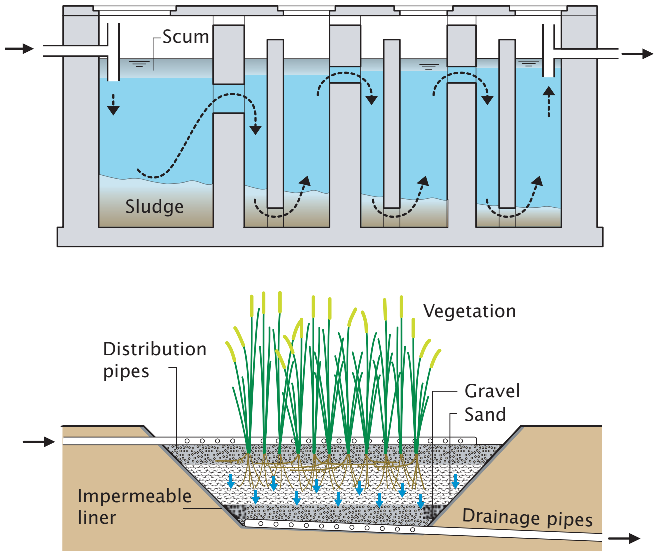

Fig. 1
The two wastewater treatment technologies investigated: Anaerobic baffled reactor (ABR, top) and vertical-flow constructed wetland (CW, bottom). (Source: Morel and Diener 2006)

industrial effluents, urban and agricultural storm water runoff, animal wastewater, and faecal sludge (Kadlec et al 2000; Mbuligwe 2004; Koottatep et al 2005). Until recently, however, knowledge about how wetlands work in Southeast Asia was not sufficiently advanced to provide engineers with detailed guidance. Our review focused on the treatment efficiency of these systems in terms of organic load (expressed as chemical oxygen demand [COD] and biochemical oxygen demand [BOD]) and nutrient removal (phosphorus, nitrogen). The exact methodology of the various experiments is described elsewhere (Khumkhom 2004; Koottatep et al 2006; Nguyen et al 2007; Sarathai 2007) and not further discussed here. Table 1 provides an overview of the projects reviewed for the present synthesis.

Institutional, legislative and socio-economic barriers to the wide-scale application of innovative technologies for pollution control at the source were analysed based on one case study in Kunming, China, and on interviews with governmental agencies and sector specialists in Thailand, Lao PDR and Vietnam. Medilanski et al (2006) relied on expert interviews adapted from Meuser and Nagel (1991) and Witzel (1982) to identify the attitudes of the most important stakeholders in Kunming towards different measures at the source for more effective wastewater management. Thirty-four interviews were conducted with stakeholders from political, administrative, scientific and business circles. The priority and feasibility of different measures at the source were evaluated based on structured interviews. The exact methodology of this study was presented elsewhere (Medilanski et al 2006) and is not discussed any further at this point.

22.3 Results

22.3.1 Anaerobic baffled reactor (ABR) and constructed wetland (CW) technologies

The projects on ABR and CW reviewed in this article (Table 1) provided scientific evidence for treatment performance and critical design parameters of these two wastewater treatment technologies, as well as valuable knowledge about their costs and the operation and maintenance requirements of the systems.

The anaerobic baffled reactor – an efficient, robust and cost-effective technology for the pre-treatment of heavily polluted domestic wastewater: The ABR has several advantages over well-established systems such

Table 1

Projects on decentralised wastewater treatment technologies reviewed in this synthesis article.

Project	References
Laboratory- and pilot-scale research on anaerobic baffled reactor (ABR) and constructed wetland (CW) in Hanoi; conducted by the Centre for Environmental Engineering of Towns and Industrial Areas of the Hanoi University of Civil Engineering (CEETIA/HUCE) and the Swiss Federal Institute of Aquatic Science and Technology (Eawag) in collaboration with Linkoping University, Sweden, and the Vietnamese Ministry of Natural Resources and Environment (MONRE), 2003–2007	Beauséjour and Nguyen 2007; Nguyen 2007; Nguyen et al 2007; MOC, in preparation
Pilot-scale research on ABR and effluent polishing systems (CW, anaerobic filter and sand filter) in Bangkok; conducted by the Asian Institute of Technology (AIT) and Eawag in collaboration with the Thai Pollution Control Department (PCD), 2003–2005	EEM/AIT 2004; Koottatep et al 2006
Laboratory-scale research on ABR treating toilet wastewater; conducted by AIT in Bangkok (PhD and MSc research), 2002–2008	Wanasen 2003; Khumkhom 2004; Sarathai 2007
Constructed wetlands for Tsunami-hit areas in southern Thailand (project funded by Danida), 2004–2007	WMA 2005; Koottatep and Polprasert 2008
On-site sanitation system for treatment of domestic wastewater on Koh Chang Island; conducted by AIT in collaboration with PCD, 2006	PCD 2006

as the septic tank or the anaerobic filter. The unique design of the ABR makes it possible to separate the hydraulic retention time (HRT) from the solids retention time (SRT) in the reactor, making the ABR a high-rate anaerobic treatment system. Treatment efficiencies of the investigated ABR systems were significantly higher than the ones observed in conventional anaerobic treatment systems. The average removal of organic material (expressed as COD) and suspended solids (SS) in the different laboratory- and pilot-scale ABRs amounted to 72–90% and 78–94%, respectively (Khumkhom 2004; Nguyen et al 2007; Sarathai 2007), which represents a significant increase compared to conventional septic tanks. Hydraulic retention time (HRT, i.e. the average time water remains in the system), wastewater up-flow velocity in the system, the number of up-flow chambers, and peak flow factors (i.e. the ratio between maximum flow rate and average flow rate) were identified as the most significant design factors (Table 2). The system proved to be simple in construction, operation and maintenance, and economically competitive. Construction costs of full-scale ABRs in Vietnam and Thailand amounted to USD 150–270 per cubic metre of reactor, or USD 35–70 per person. The main limitation of the system is its inability to remove nutrients and pathogens to levels complying with Vietnamese and Thai domestic effluent standards, so that a polishing step is required before the treated wastewater can be discharged into the environment.

The constructed wetland (CW) – an efficient polishing system with aesthetic value: Ideally, the polishing process for an anaerobically treated effluent such as an ABR effluent should be aerobic, as oxidative processes complement the reductive anaerobic processes. Linking the two types of processes in this order in a treatment chain is the most efficient way to achieve complete biodegradation of organic material. The CW systems investigated in Vietnam and Thailand (Table 1) produced an effluent with organic material and solids concentrations as low as 15–30 mg/L (BOD) and 13–23 mg/L (SS), respectively (Koottatep et al 2005; Nguyen et al 2007). All wetland systems could meet Vietnamese and Thai national domestic effluent standards in terms of organic load and nutrients. Plant species such as cattails (*Typha angustifolia*) and common reeds (*Phragmites communis*) proved to be suitable as wetland vegetation. Operational problems such as filter bed clogging, plant die-off and odour nuisance were observed in full-scale CWs, mainly due to system overload and inefficient pre-treatment. The studies revealed that a surface area of 2.5–4 m^2 per person is required, at average costs of USD 60−120 per person (land price not included). The main research findings on CWs are summarised in Table 2.

Table 2

Treatment performance, system design, operation and maintenance requirements, construction costs, strengths and limitations of ABR and CW.

	Anaerobic baffled reactor (ABR)	**Constructed wetland (CW)**
Typical application	– Primary treatment of domestic wastewater at household or neighbourhood level (5–200 people)	– Secondary and tertiary treatment of pre-treated domestic wastewater at neighbourhood level
Treatment performance	– Removal efficiency: COD = 72–90% [a,b,c,i]; SS = 78–94% [a,b,c,i]; TP = 33% [c]; TKN= 47%[c]	– Removal efficiency: COD = 80–90% [a,c]; BOD = 75–85%; SS = 80–95% [a,c]; TN = 40–60% [a,c]
System design, operation and maintenance	– 1 sedimentation chamber, 2–3 up-flow chambers [a,b,c,i] – HRT = 48 hours [a,b,c,i] – Size: 0.3–0.4 m^3 per person – Critical up-flow velocity = 0.5–0.7 m/h [a,b] – Reactor start-up period: 90 days [b] – Critical hydraulic peak flow factor = 4 [b] – De-sludging frequency: 2–3 years [a]	– Series of vertical-flow units, horizontal-flow units, free-water surface units [f]; 2 vertical-flow units in series [a] – HRT = 2–4 days [g,h] – Size: 2.5–4 m^2 per person [h] – Harvesting of wetland plants: 3–4 times per year [h] – Periodic cleansing of CW unit surface [f]
Construction costs	– 150–270 USD/m^3 of wastewater [e, g] – USD 35–70 per person [e, g]	– 400–650 USD/m^3 of wastewater [g, h] – USD 60–120 per person [g, h]
Strengths	– Simple design (no moving parts, no mechanical mixing) – High treatment efficiency (organic material and suspended solids) – High stability under organic and hydraulic shock loads – Low capital and operational costs – Plant operators do not need high-level academic qualifications	– High treatment efficiency (including nutrients and pathogens) – National wastewater discharge standards can be met – Pleasant landscaping possible – Can be cheap in construction if filter material is locally available – Plant operators do not need high-level academic qualifications
Limitations	– Limited nutrient and pathogen removals – Effluent standards cannot be met – Potential production of greenhouse gases (e.g. CH_4) unless treatment or reuse facilities are installed	– High permanent space requirement – Great care required during construction and acclimatisation

COD = chemical oxygen demand; BOD = biochemical oxygen demand; SS = suspended solids; TP = total phosphorus; TN = total nitrogen; TKN = total Kjeldahl nitrogen; HRT = hydraulic retention time.

Sources: [a] = Nguyen et al 2007; [b] = Sarathai 2007; [c] = Koottatep et al 2005; [d] = Khumkhom 2004; [e] = V.A. Nguyen (personal communication, 20 February 2008); [f] = Koottatep and Polprasert 2008; [g] = PCD 2006; [h] = T. Koottatep (personal communication, 9 April 2008); [i] = Wanasen 2003.

22.3.2 Barriers to dissemination of decentralised wastewater management

The expert interviews conducted in Kunming, China, aimed to identify the potential and the limitations of introducing pollution control measures at the source to reduce nutrient discharge to surface water bodies, mainly in the form of decentralised wastewater treatment systems. Two-thirds of the 34 interviewees supported a decentralised approach to pollution control in a general way (Medilanski et al 2007). While the current level of implementation of such at-source measures in the city of Kunming was considered low (85% considered that they are 'not at all', 'very little' or 'little' implemented), 85% of stakeholders anticipated that by 2025, these measures would be 'much' or 'very much' implemented. Despite the high priority given to the implementation of at-source measures for domestic wastewater, the feasibility of such measures is considered 'very low' to 'low' (70%) at the moment. Technical difficulties and a lack of public acceptance were mentioned as main barriers. Perspectives on the situation in 2025 are, however, more promising, with feasibility improving to 85% for domestic wastewater.

Analysis of the interest and the influence of key stakeholders in introducing at-source control measures in Kunming revealed that a small number of key political stakeholders (the Congress, the city government, the Communist Party, environmental protection authorities) are the most important barrier to wide-scale introduction of such measures. A basic initial reluctance of the key political stakeholders to support the introduction of decentralised concepts was observed. It was argued that decentralised sanitation was not prestigious and lucrative enough, that technical options were not yet available, and that the probability of success could not be demonstrated (Medilanski et al 2007).

22.4 Discussion

Decentralised wastewater management represents a valuable alternative to conventional pollution control measures. Anaerobic systems such as the ABR can be considered the core technology in such decentralised concepts, being the first step in the sustainable treatment and reuse of domestic wastewater. The advantage of the ABR compared to conventional septic tanks is its high treatment efficiency in terms of organic matter and solids removal, its stability under hydraulic and organic shocks, and its ability to operate at low liquid but high solid retention times (Koottatep et al 2005; Nguyen et al 2007; Sarathai 2007). ABR effluent still contains high levels of nutrients and pathogens, requiring further treatment in a secondary and tertiary treatment process. Koottatep et al (2005), the Thai Pollution Control Department (PCD 2006) and Nguyen et al (2007) demonstrated that CW systems are well suited as a post-treatment step. Constructed wetlands not only provide advanced treatment at reasonable costs; if well designed and operated, they also have an aesthetic value. The CW system implemented on Phi Phi Island (a Tsunami-affected tourist island of Krabi Province, Thailand; Figure 2), which treats 400 m^3 of wastewater per day, was well accepted and is frequently visited by authorities, scientists and tourists. By producing a source of irrigation water for nearby green areas, the treatment system helps to mitigate the acute water scarcity on the island. A treatment chain combining ABR and CW provides a technically and economically sound system for the treatment of domestic wastewater, and makes it possible to close the water and nutrient cycles by reusing treated wastewater in irrigation.

The expert interviews conducted in Kunming, China, indicate that decentralised approaches to pollution control are not yet perceived as an option that can be implemented on a wide scale. Interviews with key representatives of the Vietnamese Environmental Protection Agency (T.H. Ha, personal communication, 1 December 2004) and the Ministry of Communication, Transportation, Post and Construction in Lao PDR (K. Thaiphachanh, personal communication, 5 January 2007) confirmed this perception in other countries of Southeast Asia. According to Parkinson and Tayler (2003) constraints on wide acceptance and application of pollution control measures at the source may relate to inappropriate institutional and legislative frameworks, a lack of managerial capacity and availability of technical skills, and

Fig. 2 Constructed wetland system treating domestic wastewater of hotels and households on Phi Phi Island, Krabi Province, Thailand. (Photo by Thammarat Koottatep, 2007)

a lack of knowledge about and trust in technical innovations. These constraints, as well as possible measures for overcoming them, are further discussed below.

Social and political challenges: Overall, a lack of government commitment to address wastewater-related problems has led to a political and institutional environment that offers few incentives to manage wastewater effectively. The main challenge is to create informed demand for improved wastewater management systems. Advocacy at the political level is required, and at the community level there is a need for campaigns to promote the benefits of improved wastewater management. The Household Centred Environmental Sanitation (HCES) planning approach described by Eawag and the Water Supply and Sanitation Collaborative Council (Eawag and WSSCC 2005) provides a suitable framework for this purpose. The positive examples in Vietnam (Beauséjour and Nguyen 2007), China (Chuan et al 2005) and Thailand (Koottatep et al 2007), where decentralised wastewater treatment systems have been introduced in demonstration projects, indicate the important role of such projects in stimulating wider interest in the benefits of such approaches. The park-like CW system implemented in the tourist area of Phi Phi Island, Thailand (Figure 2), is frequently visited, which is evidence of its acknowledgement and reputation.

Institutional and legislative challenges: In 1997, 77% of the countries in Asia and the Pacific indicated a need to define formal wastewater management policies and enact further supporting legislation to improve enforcement (UNESCAP 1997). Performance incentives are still weak (Strauss and Montangero 2003). Official design standards are generally not framed in a way that supports the application of innovative systems such as the ABR or the CW discussed above. In China, for example, there is little legislative support for practical trials and implementation of innovative urban wastewater management systems (Medilanski et al 2007). There is a need to develop appropriate standards to be utilised for the design and construction of decentralised wastewater systems. The introduction of the ABR technology in national urban infrastructure standards of Vietnam is believed to be an important step towards its wider implementation in the country (MOC, in preparation).

Limited capacities to plan, implement and operate decentralised systems: The successful adoption of at-source pollution control measures is limited by the need to ensure that the operation and maintenance of the chosen technologies are compatible with the levels of knowledge and skills available at the local level (Parkinson and Tayler 2003). There is often a lack of knowledge about decentralised options as well as shortages in the qualified work force and the skills needed for operation and maintenance. Environmental protection agencies in Vietnam, Laos and Thailand expressed the need to disseminate technical information in appropriate forms and languages in a way that is understandable to those who are responsible for the design and operation of decentralised wastewater management systems (T.H. Ha, personal communication, 1 December 2004; K. Thaiphachanh, personal communication, 5 January 2007). In addition, most authorities express a need for training local stakeholders to enable them to understand how technologies work and what their operational and maintenance requirements are. Technical guidelines in local languages, such as those developed by Nguyen (2007) and EEM/AIT (2004) on septic tanks, ABRs or CWs in the framework of the NCCR North-South programme, facilitate transfer of knowledge from the research community to local practitioners.

22.5 Conclusion

In rapidly growing cities of Southeast Asia, decentralised technologies for wastewater treatment have a great potential for mitigating the problems of water pollution and water scarcity. We were able to demonstrate that appropriate technologies for the decentralised treatment of wastewater exist. The investigated treatment systems (ABR, CW) can be applied at household and community levels alike, and produce an effluent that allows the safe reuse of treated wastewater for irrigation. However, such treatment systems have not been widely utilised and remain restricted to localised areas and pilot projects. The fact that most experts and local authorities interviewed consider today's decentralised solutions as technically inadequate and not feasible in Southeast Asia is an indication of the ineffective transfer of knowledge from research institutions to decision-makers and practitioners. In order to overcome the barriers to widespread recognition and implementation, capacity building is required at the four levels associated with advocacy and awareness raising, development of appropriate policies, institutional reform and strengthening, and technical and managerial training. Questions arising include the role that development agencies and research institutions should and can play in building up these capacities and promoting decentralised wastewater management. Studies are needed to identify the most appropriate partnerships between central and local governmental agencies, the private sector and the communities in decentralised wastewater management schemes, taking into account the socio-economic and environmental heterogeneity of Southeast Asian countries.

Endnotes

Full citation for this article:
Morel A, Sarathai Y, Nguyen VA, Koottatep T. 2010. Potential and limitations of decentralised wastewater management in Southeast Asia. *In:* Hurni H, Wiesmann U, editors; with an international group of co-editors. *Global Change and Sustainable Development: A Synthesis of Regional Experiences from Research Partnerships.* Perspectives of the Swiss National Centre of Competence in Research (NCCR) North-South, University of Bern, Vol. 5. Bern, Switzerland: Geographica Bernensia, pp 343–356.

Acknowledgements:
The authors acknowledge support from the Swiss National Centre of Competence in Research (NCCR) North-South: Research Partnerships for Mitigating Syndromes of Global Change, co-funded by the Swiss National Science Foundation (SNSF), the Swiss Agency for Development and Cooperation (SDC), and the participating institutions.

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23 Innovative Tools for Environmental Sanitation Planning and River Basin Management in Southeast Asia

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Abstract

There is a need for new approaches to planning of environmental sanitation systems that respond to user demand and guarantee human health, while simultaneously ensuring resource conservation and environmental protection. This article presents a new planning approach that emphasises stakeholder participation and resource conservation – the Household-Centred Environmental Sanitation approach – along with a series of tools to facilitate its implementation. The tools are based on the methods of material flow analysis, quantitative microbial risk assessment and stakeholder analysis, and were developed during case studies in Southeast Asia. They can help to assess a current environmental sanitation system and evaluate potential future systems with regard to resource management, water pollution control and microbial health risks. They can also be used to identify and involve stakeholders in order to plan demand-responsive environmental sanitation systems. Relationships between the various tools and between the planning approach and the tools are discussed as a basis for their integration.

Keywords: Environmental sanitation; river basin management; household-centred environmental sanitation; material flow analysis; quantitative microbial risk assessment; stakeholder analysis; Southeast Asia.

23.1 Introduction

Conventional approaches to addressing the problems of urban environmental sanitation[9] and water pollution control have seldom been appropriate in developing countries (Zurbrügg et al 2004). New approaches should move away from end-of-pipe, supply-driven models and strive to close the water and nutrient cycle, while also responding to consumer demand. They should aim to provide users with the services these users want and for which they are willing to pay. To promote user ownership of services, decisions should be made at a level as close as possible to the source of the problem, in consultation with the people most directly affected (Eawag 2005; Schertenleib 2005).

Implementation of this type of people-centred approach to formulating ecologically sustainable environmental sanitation and river basin management concepts raises a series of questions. This contribution presents the Household-Centred Environmental Sanitation (HCES) planning approach and a series of tools to support its implementation. The tools are exemplified by case studies conducted in Kunming (China), Hanoi (Vietnam) and Bangkok and the Thachin river basin (Thailand).

23.2 Methods

23.2.1 The Household-Centred Environmental Sanitation (HCES) planning approach

The HCES approach places the household at the centre of the planning process and thus responds directly to the needs and demands of users. It is a multi-actor approach and emphasises the participation of all stakeholders in planning and implementing urban environmental sanitation services. Based on the concept of "zones" (household, neighbourhood, town/city, district/province, nation), it recommends addressing problems as closely as possible to where they occur. Only when a problem cannot be solved in a small zone is it addressed in the next larger zone. HCES is a multi-sector approach that takes account of water supply, sanitation, storm drainage and solid waste management in an integrated way. It is a "circular model" that targets resource conservation and reuse to reduce waste disposal in place of the traditional linear model of unrestricted supply and subsequent disposal (Eawag 2005).

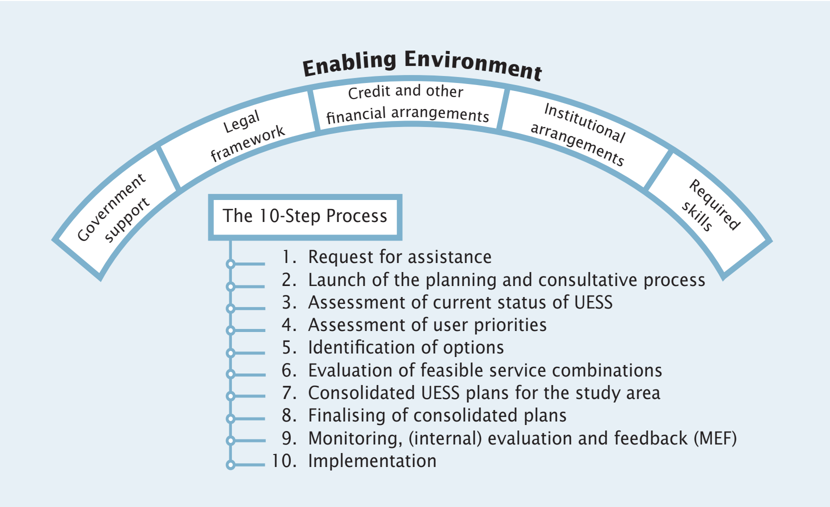


Fig. 1
The two main components of the HCES Approach: The Enabling Environment and the 10-Step Process. UESS = Urban Environmental Sanitation Services. (Source: Eawag 2005)

Guidelines for the application of this approach provide specific guidance with regard to (i) creating an enabling environment for the use of the HCES approach and (ii) undertaking a 10-step process for developing and implementing the HCES approach (Figure 1). The approach is currently being field-tested in several towns and cities in Africa, Asia and Latin America, with a focus on un-serviced or under-serviced areas in urban and peri-urban settings (SuSanA 2008).

Various methods are required to support implementation of the HCES approach. *Material flow analysis (MFA)* and *quantitative microbial risk assessment (QMRA)* can be applied to assess a given current environmental sanitation system (HCES Step 3, see Figure 1), as well as to simulate the impact of changes in the system on resource consumption, environmental pollution and microbial health risks. This, in turn, supports evaluation of potential future options, taking account of different sub-sectors such as water supply, sanitation, solid waste management and drainage in an integrated way (HCES Step 5). The results of assessments using the MFA and QMRA methods provide a basis for informed decision-making when selecting potential future options (HCES Step 6). Initiating and responding to consumer demand is one of the underlying principles of the HCES approach. *Stakeholder analysis* and involvement is therefore another essential method required throughout the entire planning process.

23.2.2 The material flow analysis (MFA) method

Material flow analysis describes and quantifies the flow of resources used and transformed as they flow through a system (e.g. a region, river basin or city). In industrialised countries, MFA has proven to be a suitable instrument for early recognition of environmental problems and development of countermeasures (Baccini and Bader 1996). In developing countries, MFA has so far successfully been used in the fields of regional water and resource management and in environmental sanitation. However, limitations in the availability and reliability of data as well as the means of compiling data are common problems faced by developing countries that restrict the use of MFA as a policy-making tool.

MFA consists of the following steps: (1) *System analysis* defines the temporal and spatial boundaries and identifies the relevant processes and flows in a system; (2) based on acquired system knowledge, the processes and flows are mathematically described (*model*); (3) *input data* for the model equations are derived from secondary data sources, expert knowledge and plausible estimations, and are continuously refined during the study; (4) the model is validated and calibrated by means of *plausibility* considerations; (5) *simulation of the current state* includes an uncertainty and sensitivity analysis to assess the model's uncertainties and identify the determining system parameters, respectively; (6) by addressing these parameters, potential mitigation measures are determined and evaluated (*scenario analysis*).

23.2.3 Quantitative microbial risk assessment (QMRA)

Quantitative microbial risk assessment is a method for predicting the consequences of potential or actual exposure of a population to infectious microorganisms and establishing associated health risks (Haas et al 1999). Methods for microbial risk assessment were first developed for drinking water and later applied to practices such as crop irrigation and discharge to recreational impoundments.

QMRA consists of four steps: (1) In *hazard identification*, the activities and pathogens that can affect human health in the focus area are identified, possible transmission routes determined, and hazard indicators chosen; (2) *exposure dose assessment* determines the exposure of the population to the indicator, focusing on pathways, concentrations, frequency of exposure, ingestion dose and the numbers of people exposed; (3) *dose-response* *analysis* is concerned with assessment of the relationship(s) between pathogen exposure and infection; (4) the risk of infection is then calculated by integrating information from the exposure and dose-response analyses (*risk determination*).

23.2.4 Stakeholder analysis

Stakeholder analysis consists of three consecutive parts (DFID 1995): (1) *Preparation of a stakeholder characterisation table* that lists all potential stakeholders, their priorities in relation to the concept being addressed (e.g. a new environmental sanitation concept) and the impact of the new concept on these priorities (positive, negative or neutral); (2) *quantification of the decision-making power of each stakeholder and stakeholder interest in the concept*, represented in a stakeholder diagram showing interest versus decision-making power; and (3) based on the stakeholder diagram, *classification of stakeholders according to their relative importance* into key stakeholders, who are the most important decision-makers; secondary stakeholders, who have little interest and decision-making power; and primary stakeholders, who are situated between these two classes. Using this diagram, conclusions can be drawn concerning the risks and potentials that affect implementation of a new concept.

23.3 Results

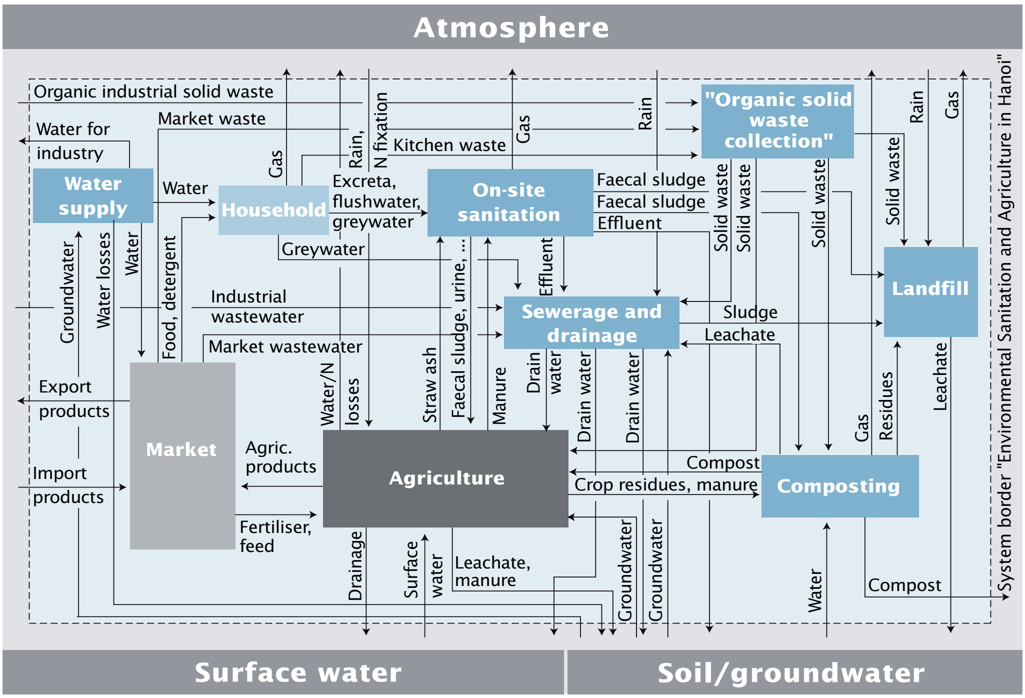
The methods presented above were further developed in case studies in Southeast Asia in order to adapt them to the requirements of the HCES approach and facilitate their application in the Southeast Asian regional context. The resulting tools – mathematical models and recommendations – are described below, and their integration in the HCES approach is discussed.

23.3.1 Tool 1: assessing potential environmental management options in the context of limited data availability

The first tool is based on the MFA method. It can be used to assess current environmental sanitation systems and evaluate the impact of interventions (scenario analysis) with regard to conserving resources and controlling water pollution. Two material flow models are presented here. Both models are based on the same modelling principles; the first describes resource flows in an urban region, the second investigates a river basin.

Assessing the impact of interventions in an environmental sanitation system: The first material flow model describes water and nutrient flows in the *environmental sanitation and agricultural system of Hanoi Province in Vietnam* (Figure 2). It was applied to simulate the impact of interventions aimed at reducing groundwater withdrawal, nutrient discharge into surface water, and the use of artificial fertilisers (Montangero et al 2007). Analysis of simulation results revealed that increasing the proportion of urine separation toilets would have a significant impact. Replacing septic tanks with urine diversion latrines could reduce phosphorus (P) and nitrogen (N) flows to surface water by 45 ± 11% and 58 ± 15%, respectively. The percentage of demand for nutrients in Hanoi's peri-urban agriculture covered by waste products would increase from 18 ± 3% to 59 ± 12% for N and from 17 ± 3% to 46 ± 9% for P. The Hanoi model can also be adapted to other urban regions in Southeast Asia, especially where on-site sanitation is the predominant wastewater disposal option. It is particularly suitable for discussing adaptations in environmental sanitation and agricultural systems, contributing to a better balance between nutrient demand and supply and thus helping to close the nutrient cycle.

Fig. 2
System analysis of environmental sanitation and agriculture in Hanoi Province, Vietnam. (Source: Montangero et al 2007)



The Hanoi case study also demonstrates the high potential of eliciting expert assessments to fill data gaps. This method enhances understanding of specific system components and provides prior probability distributions for unknown model parameters (Morgan and Henrion 1990). It is a promising method when data availability is limited and sound expert knowledge is available (Montangero and Belevi 2007, 2008).

Assessing the impact of interventions in a river basin: The second MFA model, developed in the Thachin river basin case study in Thailand, provides a basis for (1) quantifying the range of nutrient loads to be expected from the various point and non-point pollution sources in the river system; (2) identifying the key pollution flows in the basin on various spatial scales; (3) determining the key parameters responsible for these pollution flows; and (4) specifying effective mitigation measures (Schaffner et al 2009).

Analysis revealed that aquaculture is currently the dominant source of nutrient pollution in the Thachin river basin, followed by rice and pig production. Industries produce high nutrient loads, but with a considerable range of uncertainty. Other pollution sources (e.g. households, field crops and poultry production) are less significant. Scenario simulations showed that a significant reduction in the basin's nutrient loads could be achieved, for instance, by improved management of aquaculture wastewater, lower fertiliser application rates in rice farming, or optimum management of pig farm wastewater. The importance of the various pollution sources changes when the model is down-scaled to the provincial scale, thus highlighting the necessity of discussing remediation measures at an appropriate spatial scale (Schaffner 2007; Schaffner et al 2009).

This case study demonstrates the benefit of MFA in assessing the impact of pollution mitigation interventions in the particular context of intensely used lowland delta areas with complex hydrological systems (Schaffner et al 2005). The model developed can now be applied in similar river basins using average per-unit nutrient loads from the various pollution sources (transfer functions) determined in this study (Schaffner 2007).

23.3.2 Tool 2: assessing the impact of interventions on health risk

The second tool is a combined MFA and QMRA model that allows prediction of the health impacts of specific interventions. It was developed in a case study in Klong Luang municipality, a peri-urban area north of Bangkok, Thailand. MFA in this case is applied to simulate the impact of interventions on pathogen flows in specific transmission routes. The resulting pathogen concentrations at critical points in the system are then fed into the QMRA model to assess respective health risks (Surinkul 2005), which are then compared to an acceptable risk level.

In Klong Luang municipality, the possible health risks posed by *E. coli* as a result of swimming, fishing and vegetable cultivation in canals, irrigation of farmland with canal water, and raw vegetable consumption were assessed by applying a conventional QMRA that made it possible to identify the activities with the greatest health impacts. The intervention of increasing wastewater treatment showed significant potential to decrease risk (Surinkul and Koottatep 2007). The integrated MFA/QMRA model can now be applied to determine the health impacts of specific interventions (Surinkul and Koottatep 2009).

23.3.3 Tool 3: bridging the gap between stakeholder analysis and stakeholder involvement

The third tool was developed to determine the feasibility of introducing new environmental sanitation concepts, as suggested by applying Tool 1, based on stakeholders' views. An important step in this approach is validation of the stakeholder analysis, based on the perception of the stakeholders themselves (Medilanski et al 2006, 2007). Specifically, the results of stakeholder analysis are presented to the stakeholders, who are asked to discuss and comment on them. This allows stakeholders to agree on significant corrections and actively call to mind the necessary decision-making processes, and thus ensures that all stakeholders share the same view of how to proceed and that the final analysis is based on a broad stakeholder consensus.

Tool 3 was applied to assess the feasibility of introducing urine separation in Kunming, China (Figure 3). The study concluded that although a number of primary stakeholders (the main experts in ecological sanitation and environmental protection) have a great interest in testing urine separation in an urban context, most of the key stakeholders (municipal government, party and congress) would be reluctant to accept such an idea. However, a pilot urine separation project conducted in a peri-urban area in a neighbouring province showed that even a single, relatively small successful pilot project can trigger a process of broad dissemination of such technologies.

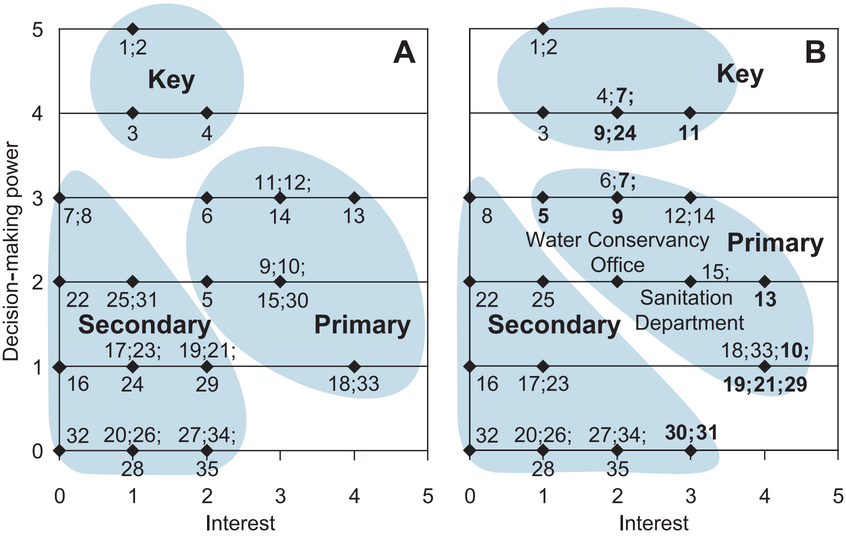


Fig. 3 Assessing the feasibility of introducing urine separation in Kunming: A) Stakeholder diagram prepared by the authors. B) Stakeholder diagram validated in a workshop with representatives of ten stakeholders. Changes recommended during the workshop are indicated by bold numbers. (Source: Medilanski et al 2007)

23.3.4 Integrating the tools in the HCES approach

Tools 1 and 2 are designed to generate a systematic overview of the entire environmental sanitation system or river basin. They help to visualise the links between different sectors such as water supply, sanitation, solid waste management, agriculture, and the environment, and thus comply with the integrated, *multi-sector* principle of the HCES approach. They comprise an assessment of the current situation and a simulation of potential options developed by a group of stakeholders. This corresponds to two main steps in the HCES approach and responds to its *multi-actor* perspective. Tool 3 is used throughout the HCES process and ensures that the designed environmental sanitation options respond to people's needs and preferences.

Tools 1 and 2 were mainly developed to be used at a single level (e.g. river basin, province, neighbourhood, or household). Analysing and visualising material flows between these levels could contribute to discussions about the appropriate level of decentralisation and hence render the integration of MFA into the HCES approach more valuable.

Effective communication is a prerequisite for successful application of the tools in the HCES approach. Information obtained about the current system and potential future options using Tools 1 and 2 should be adequately communicated to all stakeholders so as to facilitate joint development of potential options and support informed decision-making. Tool 3 should ensure communication and interaction between MFA and QMRA experts and other stakeholders.

23.4 Conclusions and outlook

Lessons learnt from the application of the new approach and the tools presented in this article demonstrate the great potential that these tools have for planning sustainable environmental sanitation and river basin management concepts. The tools provide a scientific basis for stakeholders to make informed choices, support the systematic involvement of stakeholders, and help to determine strategies for introducing new concepts in a given decision-making structure and stakeholder constellation.

In order to guarantee the development of equitable and effective interventions, it is proposed to integrate the tools presented here into a broader framework combining health, ecological, social, economic and cultural assessments (Nguyen Viet et al 2009). Such a framework could be based on the concept of critical control points (initially developed for controlling food microbial hazards), coupled with an actor perspective taking account of vulnerability to risk and patterns of resilience. The framework would jointly address health and environmental sanitation improvements, on the one hand, and the recovery of resources, on the other. It would provide a basis for designing technical solutions as well as behavioural, social and institutional changes derived from the resilience patterns identified. Possible interventions could be assessed based on their potential to minimise specific risk factors, reduce vulnerability, improve health conditions, and ensure equity.

Endnotes

Full citation for this article:
Montangero A, Schaffner M, Surinkul N, Nguyen Viet H, Koottatep T, Morel A, Lüthi C, Schertenleib R. 2010. Innovative tools for environmental sanitation planning and river basin management in Southeast Asia. *In:* Hurni H, Wiesmann U, editors; with an international group of co-editors. *Global Change and Sustainable Development: A Synthesis of Regional Experiences from Research Partnerships.* Perspectives of the Swiss National Centre of Competence in Research (NCCR) North-South, University of Bern, Vol. 5. Bern, Switzerland: Geographica Bernensia, pp 357–370.

Acknowledgements:
The authors acknowledge support from the Swiss National Centre of Competence in Research (NCCR) North-South: Research Partnerships for Mitigating Syndromes of Global Change, co-funded by the Swiss National Science Foundation (SNSF), the Swiss Agency for Development and Cooperation (SDC), and the participating institutions.

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24 Accessibility as a Determinant of Environmental Dynamics and Socio-economic Disparities in Mainland Southeast Asia

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Abstract

Access and accessibility are important determinants of people's ability to utilise natural resources, and have a strong impact on household welfare. Physical accessibility of natural resources, on the other hand, has generally been regarded as one of the most important drivers of land-use and land-cover changes. Based on two case studies, this article discusses evidence of the impact of access to services and access to natural resources on household poverty and on the environment. We show that socio-cultural distances are a key limiting factor for gaining access to services, and thereby for improved household welfare. We also discuss the impact of socio-cultural distances on access to natural resources, and show that large-scale commercial exploitation of natural resources tends to occur beyond the spatial reach of socio-culturally and economically marginalised population segments. We conclude that it is essential to pay more attention to improving the structural environment that presently leaves social minority groups marginalised. Innovative approaches that use natural resource management to induce poverty reduction – for example, through compensation of local farmers for environmental services – appear to be promising avenues that can lead to integration of the objectives of poverty reduction and sustainable environmental stewardship.

Keywords: Accessibility; social distance; poverty; forest cover change; Southeast Asia.

24.1 Background

Rural areas in mainland Southeast Asian countries are subject to intense social, economic and environmental dynamics (Hirsch 2000, 2001). This is true for Laos, Cambodia and Vietnam – the geographic focus of this article (Government of Lao PDR 2000; Rigg 2006). Emerging business and employment opportunities are bringing forth an increasing number of actors involved in natural resource use and management who differ in terms of social and economic status (Parnwell and Bryant 1996; Woods 2003; Ducourtieux et al 2005; Fullbrook 2006). This growing number of actors can increase the potential for spatially overlapping and conflicting interests with respect to natural resources (Badenoch 1999, 2002; Thomas et al 2004; Tomich et al 2004; Turner et al 2007). While traditional subsistence-oriented farming households, for instance, are likely to depend on various forest products for domestic and local consumption, more commercially-oriented entities might lay claim to the same forest for timber and utilisation of other forest resources on a larger scale.

Access and accessibility are important determinants of various actors' abilities to utilise natural resources for their own benefit. Access to markets, information and other services has been shown to have a great impact on household welfare (Grootaert 1999; Baulch and Hoddinott 2000; Diagne and Zeller 2001). Physical accessibility of natural resources, on the other hand, has generally been regarded as one of the most important drivers of land-use and land-cover changes (Chomitz and Gray 1996; Angelsen and Kaimowitz 1999; Geist and Lambin 2002; Verburg et al 2004). We argue that both physical and socio-cultural aspects of access are crucial to a place-based understanding of human–environment interactions.

Against this backdrop, we draw upon two case studies in mainland Southeast Asia to assess the impact of access to services and access to natural resources on household poverty and the environment.

24.2 Poverty–environment interactions in the development discourse

The idea that poverty and environmental degradation are causally connected, sometimes referred to as the 'poverty–environment nexus', is a much and long debated matter (Reardon and Vosti 1995; DFID 2002; Dasgupta et al 2005; Gray and Moseley 2005; Lufumpa 2005; Buys et al 2006).

In the scientific literature, some base their argumentation on the hypothesis of a vicious circle in which the poor are viewed as the chief cause of environmental degradation because of their need to overexploit natural resources to make ends meet, which in turn makes them more vulnerable and poorer (WCED 1987; Lele 1991; Bryant 1997; Scherr 2000). Others support a contrasting view, where indigenous environmental knowledge is seen as a key asset and a motivation for the poor to protect their environment (Brokensha et al 1980; Wilken 1987); from this perspective, commercialisation and intensification processes are considered to be the main causes of environmental degradation (e.g. Godoy 1984; Thrupp 1993). The idea of an environmental Kuznets curve suggests that the latter argument is true only up to a certain point of development, after which further development leads to greater environmental stewardship (Field 1997).

More recently, there has been a growing debate about the actual causes and culprits of environmental degradation in areas inhabited predominantly by the poor. Arguments range from blaming mainly traditional land-use practices, such as shifting cultivation, that are no longer sustainable due to population pressure (Myers 1993; Rambo 1996), to the contrary assertion that commercial logging, and not small-scale shifting cultivation, is to blame for forest losses and the resulting environmental degradation (e.g. Kerkhoff and Sharma 2006).

The latter view implies that even in areas predominantly inhabited by the poor, it is not necessarily the poor who are mainly responsible for environmental degradation. Other actors, who may reside outside the area and carry out some of their operations at a larger scale, might have a greater impact. Based on an analysis of international data, Redclift and Sage (1998) discussed this spatial mismatch between actors' places of residence and the locations in which they use natural resources, and also pointed out that this could lead to a spatial mismatch between resulting economic benefits and environmental degradation.

The varying impact of different actors on the environment once again raises the issue of a link between access and natural resources. An explicit and direct link between accessibility of natural resources and land-cover changes has been established in various studies (Chomitz and Gray 1996; Angelsen and Kaimowitz 1999; Geist and Lambin 2002; Verburg et al 2004; Castella et al 2005). Furthermore, natural resource users' access to services (such as credits, markets, information, etc.) has also been shown to shape land-use options and land-use practices (Leach and Mearns 1996; Lambin et al 2001).

The relation between accessibility and welfare, on the other hand, has received attention in various fields in the social sciences, particularly in the health care sector (Obrist et al 2007). Poverty proved to be an important factor in inadequate access to services (Gwatkin et al 2005). The following section discusses empirical evidence for linkages among accessibility, natural resources and poverty.

24.3 Accessibility, access, poverty and resource use: evidence from case studies

This section discusses the findings of two individual case studies: one looked at dimensions of social service accessibility and poverty in Vietnam, and the other at natural resource accessibility and forest cover changes in the lower Mekong basin. Although the two studies are not entirely comparable due to differences in both geography and the methodologies applied, some important conclusions can nevertheless be drawn.

The study that explored the relationship between poverty, natural resources, ethnicity and social service accessibility in Vietnam was based on information from the following sources: 1999 Vietnam population census data, 1999 small-area estimated household per capita expenditure data for the population of Vietnam (Minot et al 2006), official Vietnamese national forest cover and forest quality data for 1999, and spatially disaggregated information on physical accessibility of social services (Epprecht and Heinimann 2004).

People in poor areas of much of Southeast Asia tend to rely heavily on local natural resources, particularly on forest resources, for their livelihoods (Sunderlin and Thu Ba 2005). Analysing relationships between forest cover and poverty in Vietnam, Müller et al (2006) revealed that forests – as a proxy for natural resources – tend to be most abundant in areas where the incidence of poverty is highest (Figure 1).[6] However, local people often have little control over natural resources. This is due to poorly defined user and property rights (McElwee 2004; Dasgupta et al 2005), limited or unequal knowledge of harvesting and processing techniques, and lack of information on marketing potentials, to name just a few factors.

Access to services, provided in small urban population centres, proved to be a determining factor for poverty incidence in Vietnam (Epprecht et al 2009). Moreover, Epprecht et al (2009) showed that access to such services

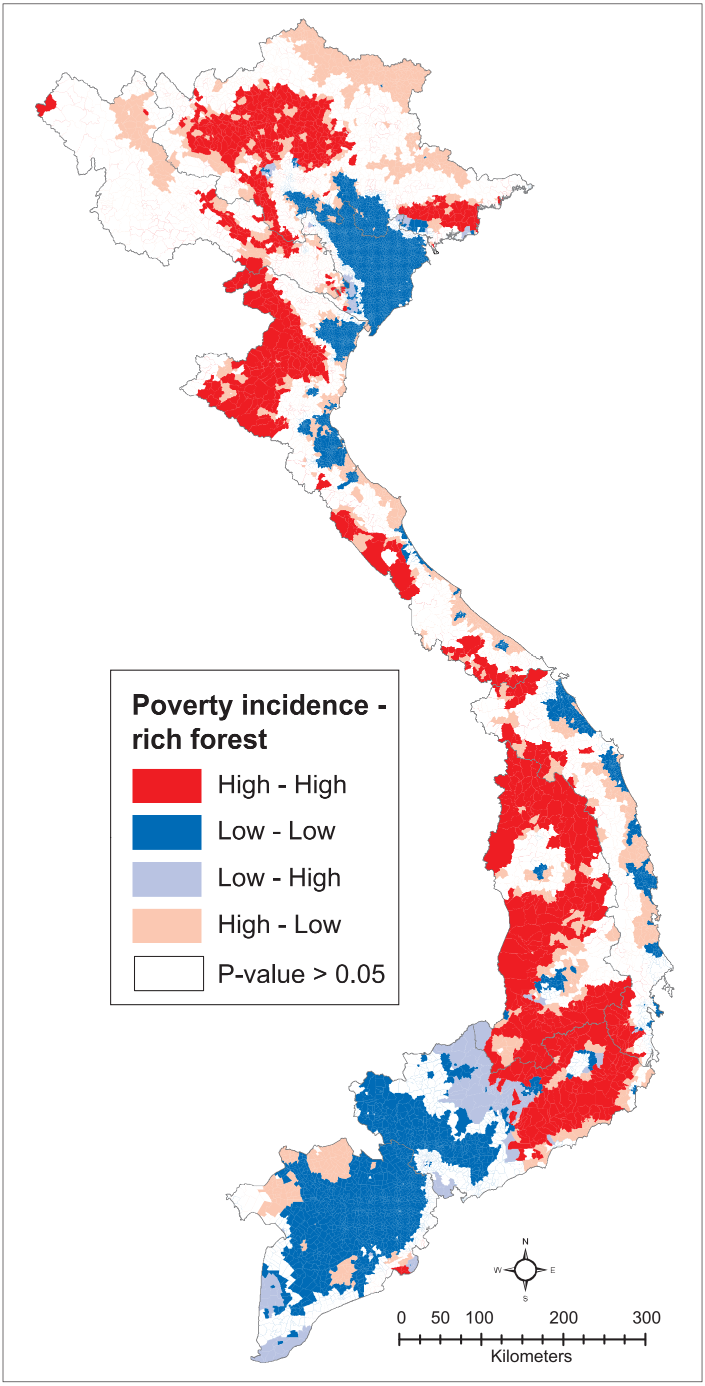
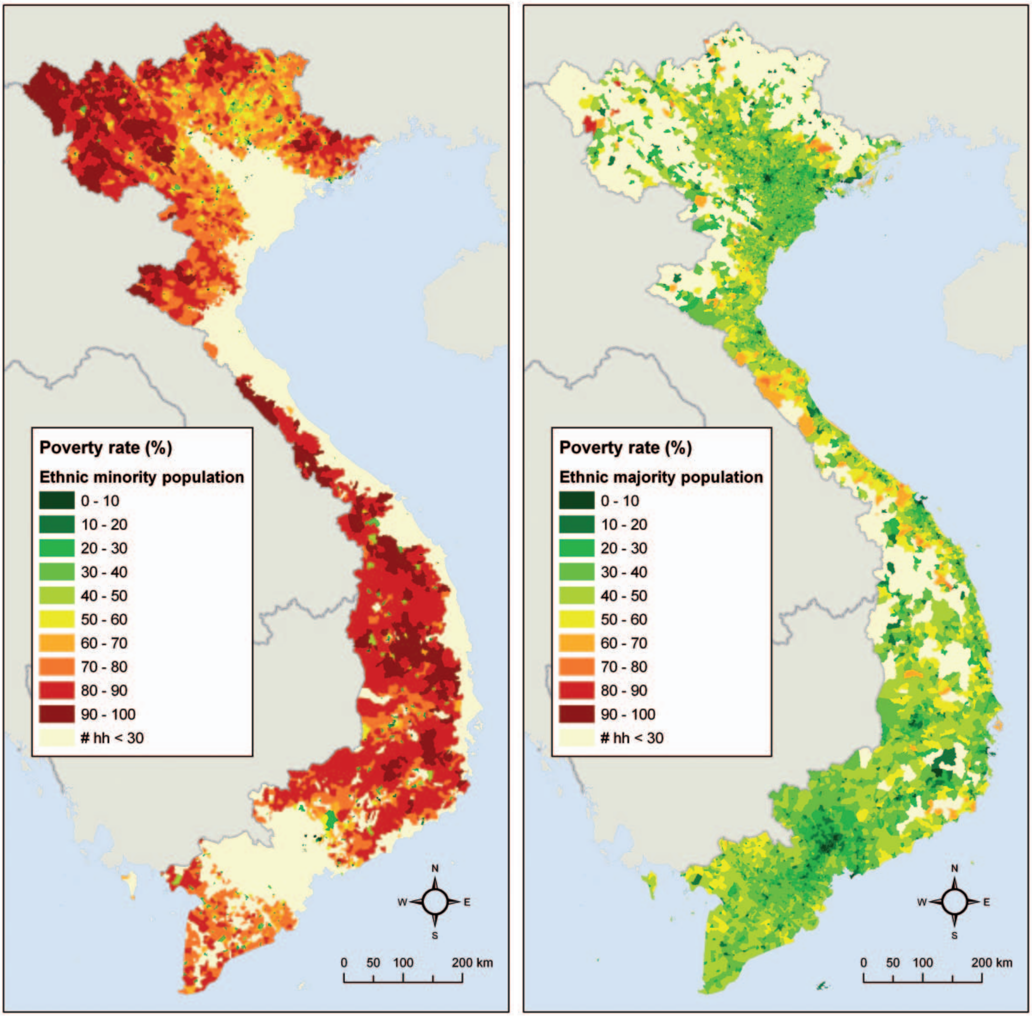


Fig. 1
Spatial coincidence of poverty incidence and forests. (Source: Müller et al 2006)

in Vietnam is determined much more by socio-cultural distance than by actual physical distance: regardless of physical access to towns, ethnic minority populations in Vietnam are consistently and significantly poorer than ethnic Vietnamese (Figure 2). Epprecht et al (2009) conclude that this finding is likely to reflect unequal opportunities for off-farm employment, lack of influence in decision-making, obstructed access to markets, services and information, and disadvantages in achieving higher levels of education.

Fig. 2
Poverty rates of ethnic minorities and the ethnic majority. (Source: Epprecht et al 2009)



The study conducted in the lower Mekong basin uses the only available and comparable regional land-cover data for 1993 and 1997, which are based on visual interpretation of Landsat imagery (Stibig 1996, 1997). The results of this study show that the accessibility of forests is a strong determinant of forest cover and forest quality dynamics (Heinimann 2006). The findings reveal that deforestation rates are significantly higher in villages closer to towns than in villages further away from towns, a fact that Heinimann (2006) attributes to a greater extent of commercial use of forest resources in areas closer to towns due to better marketing opportunities (Figure 3). However, most of the loss of economically and ecologically valuable dense forests nevertheless occurs far away from villages. Heinimann et al (2007) point out that the patterns of forest cover changes indicate that change in forest cover near villages occurs mainly in the form of forest degradation as a result of subsistence agriculture, whereas change in forest cover in more remote areas occurs mainly in the form of deforestation due to large-scale commercial activities that exploit the forest.

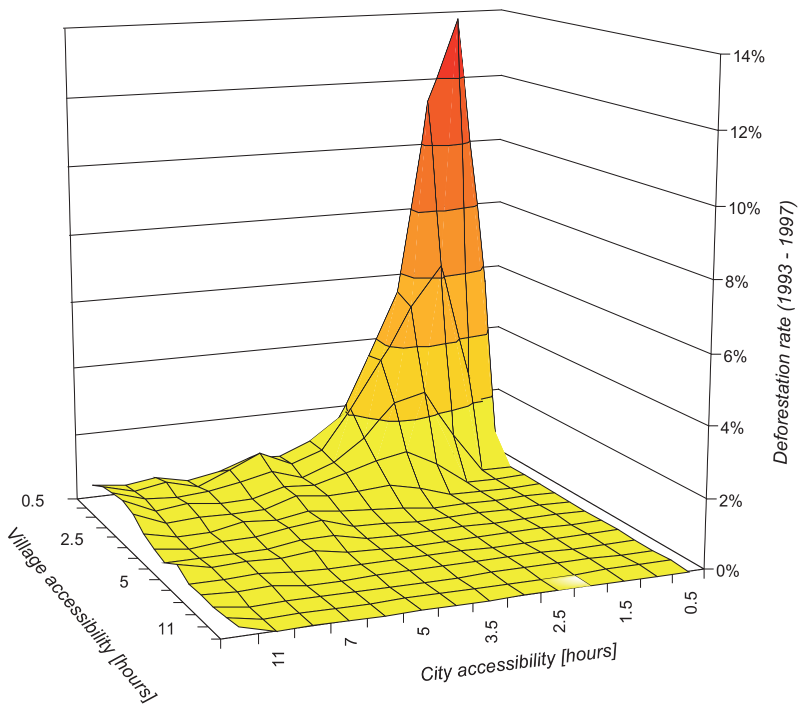


Fig. 3 Deforestation rates in the lower Mekong basin in relation to village and city accessibility. (Source: Heinimann 2006)

24.4 Discussion

The two studies confirm that physical accessibility is an important precondition for access to natural resources, and at the same time a strong determinant of welfare. In addition, socio-cultural distances proved to be a key limiting factor for access to services in Vietnam, and hence an additional factor determining household welfare. This reflects unequal opportunities among actors competing for access to and use of available natural resources. Access to local natural resources is only partially a function of their physical accessibility; it also depends on socio-cultural distance from the respective decision-makers. Despite good physical accessibility of local natural resources, local ethnic or other social minorities may have little control and few rights with regard to use of these resources, resulting in potentially limited access to resources.

On the other hand, improving physical accessibility of natural resources and markets for people in remote places may also improve access to these resources for commercially-oriented actors who tend to live in population centres and who are economically better off. This raises the question of which effect is stronger: Does improved physical accessibility – which is very likely to lead to some form of increase in commercial use of natural resources in the newly accessible places – mainly benefit local actors through better access to markets, or does it mainly improve access to natural resources for external actors? And how is this reflected in land-cover change patterns at the meso-scale?

Physically less remote and socially less marginalised people are largely better off in terms of financial and technical means, information, and possibly political influence (for example with regard to land-use rights). It is therefore plausible to assume that these actors benefit more from changes in accessibility of natural resources than actors who are more marginalised in a socio-economic sense. On this basis one would expect an increase in commercial exploitation of natural resources near villages that have become more easily accessible.

However, this is not supported by the results of the research conducted in the lower Mekong basin. Findings here revealed that commercially-motivated larger-scale activities resulting in forest loss occur mainly in areas that are not easily accessible from local villages. Forest resource use activities close to villages were shown to result in forest degradation rather than deforestation. These dynamics cannot be attributed to any specific actors on the basis of the two studies presented here.

Based on the findings of the two studies, we conclude that large-scale commercial natural resource exploitation tends to occur beyond the spatial reach of marginalised population segments. It is not possible to say conclusively whether increased forest degradation patterns in villages closer to urban areas are due to actors exploiting nearby natural resources for commercial purposes, or whether they are a result of activities conducted mainly by those who have better access to the respective resources. It is likely, however, that in many cases the poor lack the means to transport natural resources to markets far beyond their village area for commercial use, while the better-off typically do have the means to travel further to extract resources. Furthermore, although predominantly subsistence-oriented actors may engage in unsustainable natural resource use practices (e.g. for reasons of economic survival), it is likely that these actors' dependency on natural resources for their very survival makes them more cautious compared to spatially disconnected, purely commercially-oriented actors.

Although empirical evidence from these two studies does not conclusively show that improvement of physical accessibility primarily benefits commercial actors in terms of access to natural resources for commercial use, it is likely that physical accessibility – although necessary for poverty reduction as part of an effort to provide market opportunities and access to services – may have a negative impact on the local population.

24.5 Conclusion

Development dynamics in the form of rural commercialisation and an increase in the physical accessibility of ever greater parts of the region are fast-paced. Yet progress in ensuring the structural framework that must accompany these developments is relatively slow and time-consuming. This relates, for example, to guaranteeing land-use rights, improving the educational status of the local population, and providing adequate and timely information on available services in local languages. In this respect, efforts to reduce poverty accompanied by simultaneous environmental conservation or protection remain a big challenge.

Present power constellations, the slow pace of 'empowerment' of local communities through legal and educational improvements, and the high demand for and value of local resources at the regional level are an imminent threat to the local poor, and a long-term threat to the environment.

It is therefore essential that more attention be paid to improving the structural environment that presently leaves minority groups socially, economically and geographically marginalised (for example by ensuring faster devolution of land-use titles and developing legal mechanisms to claim and defend these rights). Innovative approaches that use natural resource management to induce poverty reduction – for example by compensating local farmers for environmental services as proposed by Gouyon (2003), Gutman (2003), the FAO (2004), and Wunder (2005), or more recently by compensating developing countries for reducing carbon emissions from deforestation (REDD) (Ebeling and Yasué 2008) – appear to be promising avenues for integrating the objectives of poverty reduction and sustainable environmental stewardship.

Consequently, future research within the framework of the Swiss National Centre of Competence in Research (NCCR) North-South programme in Southeast Asia will aim to link environmental service approaches with local people's access to information and services, their practices and options with respect to natural resource use, and the resulting impacts on household welfare. This will help to improve efforts to alleviate poverty and promote natural resource management.

Endnotes

Full citation for this article:
Epprecht M, Heinimann A, Messerli P, Schmidt-Vogt D, Wiesmann U. 2010. Accessibility as a determinant of environmental dynamics and socio-economic disparities in mainland Southeast Asia. *In:* Hurni H, Wiesmann U, editors; with an international group of co-editors. *Global Change and Sustainable Development: A Synthesis of Regional Experiences from Research Partnerships.* Perspectives of the Swiss National Centre of Competence in Research (NCCR) North-South, University of Bern, Vol. 5. Bern, Switzerland: Geographica Bernensia, pp 371–384.

Acknowledgements:
The authors acknowledge support from the Swiss National Centre of Competence in Research (NCCR) North-South: Research Partnerships for Mitigating Syndromes of Global Change, co-funded by the Swiss National Science Foundation (SNSF), the Swiss Agency for Development and Cooperation (SDC), and the participating institutions.

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[6] For details on the methodologies, see Müller et al (2006) and Sunderlin et al (2008).

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