Sida Evaluation 2008:27

The Asian Regional Research Programme on Environmental Technologies (ARRPET)

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Department for Research Cooperation

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Abbreviations

3D	3-Dimensional
ABC	Atmospheric Brown Cloud
ADB	Asian Development Bank
AIRPET	Improving air quality in Asian developing countries, SMA of ARRPET
AIT	Asian Institute of Technology
AOX	Adsorbable Organic Halides
AQM	Air Quality Management
ARRPET	Asian Regional Program on Environmental Technologies
ARRPEEC	Asian Regional Research Program in Energy, Environment and Climate
ARW	Annual Review Workshop
BLL	Blood Lead Level
BOD	Biological Oxygen Demand
BSc	Bachelor of Science
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CAI	Clean Air Initiative
CBA	Cost-Benefit Analysis
CIDA	Canadian International Development Agency
CMB	Chemical Mass Balance
DSA	Daily Subsistence Allowance
EIA	Environmental Impact Analysis
EEPSEA	Environment and Economy Program for S-E Asia
ha	Hectare, equaling 10,000 m2
IDRC	International Development Research Centre of Canada
IF	(Scientific Journal) Impact Factor
IHWTM	Industrial and hazardous waste treatment and management SMA of ARRPET
INEC	Department for Infrastructure and Economic Cooperation (Sida)
IPR	Intellectual Property Rights
LFA	Logical Framework Approach
MSc	Master of Science
NATUR	Department for Natural Resources and the Environment (Sida)
NIP	National Implementation Plan (of UNEP Stockholm Convention)
NOx	Nitrous Oxides
NRI	National Research Institute
PAH	Polycyclic Aromatic Compounds
PCB	Polychlorinated Biphenyls
PhD	Doctor of Philosophy
PI	Principal Investigator (Leader of an ARRPET research program)
PM	Particulate Matter
PM2.5	Particulate Matter that is 2.5 micrometers or smaller in size
PM2.5–10	Particulate Matter that is 2.5–10 micrometers in size
PMF	Positive Matrix Factorisation
POP	Persistent Organic Pollutants
QA	Quality Assurance

QC	Quality Control
RERIC	Regional Energy Resources Information Center (at AIT)
RETs	Renewable Energy Technologies
RDF	Refuse Derived Fuel
RP	Resource Person
SAREC	Department for Research Cooperation (Sida)
SEATO	South East Asia Treaty Organization
SENSA	Swedish Environment Secretariat in Asia
Sida	Swedish International Development Cooperation Agency
SMA	Subject Matter Area
SWLF	Sustainable solid waste landfill management in Asia, SMA of ARRPET
SWM	Solid Waste Management
TL	Team Leader
ToR	Terms of Reference
UEMA	Urban Environment Management Program
UNEP	United Nations Environmental Program
UV	Ultra Violet
VEPA	Vietnam Environment Protection Agency
VOC	Volatile Organic Compounds
WHO	World Health Organization
WWTM	Wastewater treatment and management SMA of ARRPET

"Regional research programs are very different from other programs. I have really learned a lot from my colleagues in this program. It is hard work, but I am very happy that I am involved in this."

(Comment by an ARRPET network member)

Executive Summary

Introduction

The Asian Regional Research Program on Environmental Technologies (ARRPET) is a research and technology development program covering 18 National Research Institutes (NRI) forming a network in eight countries. The activities are financed by the Department for Research Cooperation (SAREC) of the Swedish International Development Cooperation Agency (Sida) and coordinated by the Asian Institute of Technology (AIT) in Thailand, which is the contract partner. AIT in turn, has formal agreements with the NRI in China, India, Indonesia, Malaysia, the Philippines, Sri Lanka, Thailand and Vietnam. The NRI contribute with researchers, staff and infrastructure.

Phase I of the program was from 2001–2004. Phase II functioned until 2007, with a concluding period of operation in 2008. In Phase I 24 million SEK and in Phase II 32 million SEK were allocated.

ARRPET shall conduct research on environmental issues – Wastewater, Solid Waste, Air Pollution and Hazardous Waste – relevant to Asia. The four issues are treated as overarching subject matter areas (SMA), organizing the NRI. A Swedish Resource Person is attached to each SMA. The main objectives are, in short:

- To mobilize and strengthen scientific competence and capacity in fields relevant for national and regional initiatives for controlling urban and environmental pollution.
- To generate good quality research relevant to the Asian region
- To develop technical solutions to environmental problems, and
- To disseminate the results in order to have an impact on policy plans.

These objectives were generally well achieved, whereas impact on policy plans remains to be fulfilled.

Summarized Findings

The creation of ARRPET was timely and to develop technical solutions to environmental problems and adapt these to local situations was, and still is, an appropriate goal. ARRPET has been successful in mobilizing and strengthening scientific competence and capacity at most NRI, and has initiated systematic environmental research and thinking at the participating laboratories. The research projects are relevant to regional environmental challenges. Good quality research has been produced, in most cases in a fruitful combination of scientific excellence and technical applicability. However, some needs have been identified, for example in the gap between developing models and applying them.

Dissemination of results, e.g. in international scientific journals, has been satisfactory, although some NRI have not contributed to the expected level; they would have benefitted from better support routines within the network. There have been substantial variations between SMA and NRI with respect to dissemination. In many cases there is considerable room for improvement of outreaching activities directed to decision- and policymakers, and for the general public, through the media. Some NRI have been very successful, though.

As recently as 20 years ago, scientific research in some ARRPET member countries was at a very low level by international standards and articles from these countries in international peer-reviewed journals very rare. Presentations at international conferences were equally rare and presentation techniques weak. In this respect, ARRPET has had a remarkable effect; several presentations have won awards at international conferences.

Several studies have provided technical solutions to environmental problems. The technical outcome varies, and ranges from industrial, microbial reactor-based purification techniques (in several cases implemented at a pilot plant stage) to the establishment of regional monitoring programs. However, in most cases tentative end-users (industry/regulators) were not involved early enough to have had an initial influence on feasibility and relevance.

Networking has been well developed, but scientific support to less resourceful NRI could have been more effective. On the administrative level AIT support has been most valuable. The division, distribution and utilization of funds has generally worked well.

External co-funding has been scarce, although national funding was available in some cases. Internal co-funding "in kind" has been substantial. The NRI contribute with researchers, staff and infrastructure thereby promoting ownership. Unfortunately, the ARRPET website does not mention this. Most NRI have been totally dependent on ARRPET, with regard to the research activities within the network, which implies high vulnerability. At the pilot scale level, however, industrial partners have usually been involved in funding. The program did not offer PhD scholarships but this would have improved quality and continuity.

The Swedish Resource Persons were seen as a welcome and influential resource. However, they were engaged at a stage too late to influence the selection of research areas. Furthermore, their mandate was not clearly spelled out. The participants saw them as their resource, while the primary intention seems to have been that they should be reviewers and advisors to Sida/SAREC.

Several contacts between ARRPET researchers and regulators and authorities can be expected to influence policies in the long run. However, with regard to disseminating results to decision- and policymakers and to strengthening environmental protection activities by linking to regional initiatives, much remains to be explored.

Overall gender balance is fair, but females are underrepresented at leadership levels. With regard to equity, some less resourceful NRI were not supported to the extent desirable.

In particular, these positive effects were observed:

- Co-operation across geographical borders meant that resources and skills were pooled, and that dispersed competence was combined into a stronger and more effective entity.
- Researchers have been trained in peripheral skills, such as organization of conferences, presentation skills and reporting skills.
- A large number of students have been able to use ARRPET projects for their thesis.
- In many cases, methods have been harmonized, and standardized techniques adopted.
- Some influence on environmental standards and regulations is evident, as is increased awareness among decision- and policymakers.
- Some industries and small scale companies have improved their processes as a result of the research projects

Recommendations

It would be highly valuable to take advantage of the structure, knowledge and competence developed by ARRPET in research and technology and in networking by continuing to facilitate and support. A third phase would need to be allowed four to five years and be based on experiences and lessons learned during the first and second phase.

Among general recommendations are:

- Review objectives taking into account emerging needs in the environmental arena, such as concern about climate change.
- Establish an open fund for these emerging needs and, to improve continuity, provide scholarships for PhD students.
- Concentrate on a few, major issues and increase cooperation between SMA
- Involve social sciences, e.g. to account for socio-economical implications of possible implementations.
- Support increased dissemination by training and by providing English language support,
- Assist scaling up of research for future commercial implementation where this is feasible, in particular when research potential exists in these applications.
- Enhance the exchange of researchers on all levels in the network by e.g. more frequent and longer regular meetings and short-term exchange programs
- Make better use of the Resource Persons by supporting their direct involvement in and scientific contribution to the research activities.
- Further develop the use of the ARRPET website as a common resource in order to encourage interaction between the NRI but also to provide more efficient dissemination of results.

Application of a similar approach in African South of the Sahara could be successful with these prerequisites.

- The initiative must be truly demand driven building on "win-win" collaboration with local partners
- Acceptance at high political levels and their involvement in planning.
- An interdisciplinary approach, involving social sciences.
- Potential end-users (industry/regulators) consulted at an early stage of planning.
- The role of resource persons to include research cooperation.
- An institution corresponding to AIT with knowledgeable, resourceful and strong leadership.
- A capacity building element to be considered where necessary.
- Scholarships to PhD students should be included, perhaps organized as a research school.

1 Introduction

1.1 General

The Asian Regional Research Program on Environmental Technologies (ARRPET; www.arrpet.ait.ac.th) is a research and technology development program covering 18 National Research Institutes (NRI) in eight countries. It is financed by the Department for Research Cooperation (SAREC) of the Swedish International Development Cooperation Agency (Sida) and coordinated by the Asian Institute of Technology (AIT) in Thailand.

A Phase I of the program was launched in 2001. Funds were received by AIT the same year and released to NRI in 2002. Phase 1 was completed in June 2004. Thereafter, the program continued with a Phase II, financed until 2007, and with a concluding period of operation in 2008.

The aim of ARRPET I was to conduct research on environmental issues relevant to Asia. These issues included wastewater, solid waste, air pollution and hazardous waste.

Research in ARRPET II continued within the areas of treatment and management of domestic as well as agro-based industrial wastewaters; pressing air pollution issues relevant to the Asian developing countries; enhancing solid waste disposal practices and landfill technology for efficient and effective solid waste management in the region; and removal of toxic and hazardous compounds from industrial discharges.

1.2 SCOPE, Objective and Methodology of the Evaluation

The scope of this evaluation includes the performance of ARRPET from its start in 2001 (ARRPET I) but focusing on the current phase starting in 2004 (ARRPET II; See Appendix 1, Terms of Reference; ToR).

The objective is to assess network performance, scientific quality and relevance, as well as impact both on participating NRI and on national policies. The evaluation does not cover financial management and the team has made no attempt to audit the projects financially. The evaluation should also situate the regional program approach within the global context and debate on environmental technology research as a means to reduce poverty which is the ultimate development objective.

Our starting point in the evaluation is (see Section 4.1 for details):

- The primary objectives stated in the Sida memorandums on ARRPET I and II
- The questions posed in the Sida ToR
- The Logical Framework Approach (LFA) matrices constructed at Theme and NRI levels

The evaluation methodology is comprised of document analysis and standardized interviews including structured observations at site visits to each NRI by one or more of the evaluation team members. The interviews used questionnaires (Annex 2). The evaluation started in August 2007 with a Fact-Finding Mission (Section 5.3). Here the ARRPET Coordinator, the President of AIT, Principal Investigators (PI), some Team Leaders (TL), researchers and students, as well as the Swedish Resource Persons (RP) were interviewed. To ensure reliability and validity, the questionnaires for the three different groups of stakeholders (Coordinator and AIT president, PI and TL, and RP, respectively) contain similar elements. Later in 2007 this approach was complemented by site visits, with in-depth interviews based on questionnaires sent out beforehand and reviews of documentation. A telephone meeting with the ARRPET coordinator was held in September, before the visits to most of the NRI. The evaluation

team also participated in the ARRPET Annual Review meeting at AIT, 12–14 November 2007, where provisional findings were presented. All relevant reports – proposals, agreed minutes, conference proceedings, scientific articles, etc. – have been made available to us for analysis.

2 Background

2.1 Contract Partner – Asian Institute of Technology

The contract partner of Sida/SAREC is the Asian Institute of Technology (AIT). AIT in turn has formal agreements with the 18 NRI that constitute the ARRPET network. Auditing is done by the respective NRI, and they are responsible for producing progress reports according to a schedule laid out in the contract between the NRI and AIT. Audits and progress reports are consolidated by the Coordinator and submitted to Sida/SAREC by AIT.

AIT is an international post-graduate institution of higher learning on a 160 ha campus located in Rangsit, 40 km north of Bangkok. AIT was founded 1959 to help meet the growing need for advanced engineering in Asia. Besides the main campus in Thailand, it operates two centres in Vietnam. AIT provides post-graduate education in engineering, Professors Said Irandust and Ajit Annachhatre science, planning and management through short courses, master programmes and doctoral research via three "Schools" (faculties), one of which is the School of Environment, Resources and Development. ARRPET is organised at this School.

AIT Mission: "To develop highly qualified and committed professionals who will play a leading role in the sustainable development of the region and its integration into the global community"

AIT Governance: The current President of AIT is Professor Said Irandust (previously Rector of Borås University, Sweden). The Chairman of the Board of Trustees is Tej Bunnag (Thailand). AIT is in the curious position of not having an owner; this means it has no core funding, but relies on tuition fees and donor support. It was established by the South East Asia Treaty Organization (SEATO), but this organization ceased to exist many years ago.. AIT is actively trying to establish itself as an international organization. AIT would then be exempt from taxes and duties – presently about 80 million Baht per year.

AIT Students: The total enrolment is about 2,000 students from around 40 countries with most coming from Thailand, Vietnam, Nepal, China, Bangladesh, Cambodia and Laos. According to the President, the number of master students increases by about 5% each year, while PhD numbers increase by about 11% per year.There are close to 400 PhD students.

Students at AIT are of two categories: those that select AIT as an alternative to other universities and finance themselves, and those financed by donors in the expectation that they will contribute to national capacity building. To attract the first category a university must be seen as providing academic excellence. The second category requires a curriculum relevant to regional needs. An ongoing reform process considers how to match these somewhat disparate requirements. The Swedish Ambassador is actively involved in the reform process.

AIT Finances: Revenues are about 300 million SEK/year. Thailand provides most with Sweden now being the second largest source. Quite a number of countries contribute to AIT and donations can be either in cash or in kind, such as seconded staff – from Finland, France and Switzerland for example. Support from Sweden comes from three divisions of Sida: SAREC provides support for research, NATUR for

master students and INEC for some projects related to energy). A few years ago AIT had a large financial deficit, but this is now cleared and the financial situation is satisfactory with a healthy reserve.

AIT Strengths: AIT positioned itself early as a leading regional higher learning institute. Students come from different countries in the region and AIT has actively developed a strong network of former students. Since many of these 14,000 alumni are now in key positions AIT it has come to play an important role in the development of the region. This role is further strengthened through its extension activities and through international organizations that have decided to locate their offices on the AIT campus. AIT offers its alumni many refresher courses..It is thus more than just a university and this has attracted support from development agencies. AIT has a good reputation for taking special care of students from countries with a weak education system (Vietnam, Cambodia, Laos, etc) and with little knowledge of English as medium of instruction.

AIT has played a very active role in the modernization of Asian countries, and can be expected to continue to be an important instrument in the development of the region.

2.2 Related Programs

A number of related programs are operating in the region.

2.2.1 Sida-funded research networks in Asia

SAREC financed during a period of seven years two regional programs on renewable energy of a model similar to ARRPET. *Renewable Energy Technologies (RETs)* in Asia (http://www.retsasia.ait.ac.th) was a regional research and dissemination programme also coordinated by the Asian Institute of Technology (AIT). It was initiated in 1997 to promote renewable energy technologies in six Asian countries. Activities of Phase I (1997–1998; Khennas & Andersson, 1999) and Phase II (1999–2001) mostly concentrated on adaptive research and demonstration of those technologies suitable to the local condition. Phase III (2002–2004) emphasized dissemination. RETs packages for selected areas were identified and demonstrated on a commercial/semi-commercial basis. A sister program, Asian Regional Program in Energy, Environment and Climate – ARRPEEC (http://www.arrpeec.ait.ac.th/), on energy and greenhouse gases ran concurrently (Christensen & Mackenzie, 1998; Björklund & Chadwick, 2004).

There is also a regional research program, on sustainable agriculture, called *"Mekarn"* (http://www.mekarn.org) that covers South East Asia. It is regarded as a successful example of a network of networks and may have provided inspiration for ARRPET. This network, coordinated by Nong Lam University in Ho Chi Minh City, is entirely financed by SAREC. Participants are institutions in the Lower Mekong Basin (Laos, Vietnam, Cambodia and Thailand). The core activities are research, research training, and exchange and dissemination of information.

SAREC established together with IDRC the *"Economy and Environment Program for Southeast Asia", EEPSEA* (http://www.idrc.ca/en/ev-7199-201-1-DO_TOPIC.html), in 1993 to support training and research in environmental and resource economics. Its goal is to strengthen local capacity for the economic analysis of environmental problems so that researchers can provide sound advice to decision- and policymakers. The program uses a networking approach to provide not only financial support but meetings, resource persons, access to literature, publication outlets, and opportunities for comparative research across its nine member countries. These are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Laos, China and Papua New Guinea.

2.2.2 Research networks similar to ARRPET funded by other donors

AIT coordinates several regional programs besides ARRPET. One of these, the *South East Asian Urban Environmental Management Program* (UEMA; http://www.sea-uema.ait.ac.th), bears some resemblance to ARRPET. It is financed by the Canadian International Development Agency (CIDA) and covers Indo-

nesia, Laos, Philippines, Thailand, Vietnam and Timor. It concentrates on solid waste, water and sanitation, and air pollution. Within this program there are research activities, but unlike ARRPET, it includes scholarships at MSc and PhD levels. Post Doc positions are also available. Rather than compete, ARRPET and UEMA complement each other.

2.3 Origin of ARRPET

Sweden had few contacts with AIT before 1990, and the first contacts concerned the possibility of providing scholarships for students from Vietnam and Laos. SAREC then initiated discussions with AIT in the early 1990's to find out whether it could take on the role of coordinating two regional programs on environmental technologies. These discussions led to the creation of the two regional programs, ARRPEEC and RETs, mentioned above. Both programs are now closed.

Towards the end of the operation of these two regional programs it was felt natural to continue with a new regional research program on environmental technology in line with the, then, new Asian strategy ("Asiatiska Vägval") that the Swedish Ministry of Foreign Affairs had just released. At that time few countries in Asia were considered to have any capacity to undertake research on environmental technology. SAREC stipulated that the program was a research program and not a capacity-building program. Scholarships could not be included, salaries not paid and no heavy equipment purchased. Activities had to be limited to research and no provisions for scaling up successful research findings to a pilot scale were provided. With regard to finding participating NRI, the puzzle was to take account of what experience was available in the different countries while trying to arrive at a coherent program. This was a sensitive issue as there was an obvious dichotomy in the desire of SAREC to involve weaker countries, while and at the same time base selection on competition through merit. It is our opinion that AIT solved this issue in an acceptable way. One outcome was that the two most advanced countries, India and China had to be involved in all four subject matter areas and countries like Laos and Cambodia had to be left out, at least for the time being. Besides India and China, the countries involved were Indonesia, Malaysia, the Philippines, Sri Lanka, Thailand and Vietnam.

The NRI were selected primarily by using the AIT network of research contacts and alumni. It may be an advantage to involve persons with known capacity and interests. In some Subject Matter Areas, where Sida/SAREC specifically asked for participants from certain countries, but where contacts were not well enough developed to identify a suitable NRI, several universities where approached and invited to apply for participation. This was the case for example for Sri Lanka in the Industrial Hazardous Waste Treatment and Management (IHWTM) Subject Matter Area.

For the Sustainable Solid Waste Landfill Management (SWLF) Subject Matter Area, the original project proposal was sent to several researchers in the region. Some of these were recommended by Dr Bagavan who had worked with the ARRPET application on solid waste. Institutions interested sent a Declaration of Interest to AIT. These were evaluated by AIT and Sida according to two criteria:

1) An existing research culture (or expressed interest to develop one);
2) Laboratory equipment/facilities available.

These criteria were set to be able to pick NRI that could contribute i.e. mobilising and strengthening (not building) research capacity in the region. Here too, most senior researchers finally involved in the project had had earlier contacts with AIT (alumni or former teachers).

Discussions eventually led to the creation of the present ARRPET program that initially included 21 NRI. Three NRI have since been dropped mainly because of non-delivery.

ARRPET Phase I, which commenced from January 1, 2001, was completed on June 30, 2004. ARRPET Phase II, besides continued research, aims at application of some results from ARRPET I at

pilot scale. The ARRPET Phase II agreement extended to December 31, 2007. However, in 2007 an amendment to the agreement was made, allowing the use of Sida funds until 31 August 2008, with an extension to 31 March 2009 for final reporting. AIT plans to submit a proposal to Sida/SAREC for a Phase III of the ARRPET program.

3 ARRPET Project Structure

3.1 ARRPET Organization

The ARRPET program is led by a Coordinator based at the AIT campus in Rangsit, Thailand, and is divided into of four Subject Matter Areas (SMA; on the ARRPET website and in the ARRPET documentation sometimes called Themes or Projects):

- Wastewater treatment and management (WWTM)
- Sustainable solid waste landfill management in Asia (SWLF)
- Improving air quality in Asian developing countries (AIRPET)
- Industrial and hazardous waste treatment and management (IHWTM)

The four SMA are organized as networks of participating researchers connecting national research institutes (NRI). AIT functions as NRI at all SMA. ARRPET can thus be described as a network of networks, where AIT is both as an administrative hub and a scientific node.

In general, the term network can refer to any interconnected group or system. In ARRPET, the NRI networks within the SMA address common or similar research areas, with the specific benefits common understanding and methods may bring about. The overall ARRPET network, comprising all NRI including ARRPET, has the potential to create common understanding of environmental problems in general.

Each SMA is led by a Principal Investigator (PI; sometimes referred to as Theme or Project Leader), and has a Swedish Resource Person (RP). Three of the PI are based at the AIT campus, one of those also being the Coordinator, and one is based at the Indian Institute of Technology, Kanpur, India. The four PI form an informal Steering Group, responsible for execution, quality and administration of ARRPET.

Each SMA today has five to six participating NRI. The total number of participating NRI is 18. Two of the institutes are involved in more than one SMA. Three further NRI participated in ARRPET I, but were excluded from the program, because they failed to deliver according to the agreement in Phase I. This was decided in the transition between Phase I and II.

At each NRI the research team is led by a Team Leader (TL; although these sometimes refer to themselves as PI). The Teams vary in size, they usually consist of a core of a few researchers and technicians, with other staff participating temporarily or part time. Students attached to the Teams are usually on BSc and MSc levels, doing project work within the ARRPET research subjects. A few teams have PhD students involved under separate funding.

Participating NRI may be involved in more than one ARRPET research project at the same time, one on a major issue and one or a few on minor issues. The progress of the research program has been documented in scientific reports and meeting minutes, many of which are available at the ARRPET website (http://www.arrpet.ait.ac.th).

Participants from all NRI meet annually at an Annual Review Workshop (ARW) where progress for each project is presented and discussed. Six months after the ARW the SMA hold Regional meetings – the WWTM and IHWTM SMA usually together. In addition, SMA have national meetings.

Coordinator of ARRPET
Prof. Ajit P. Annachhatre, AIT, Bangkok, Thailand
Wastewater Treatment and Management (WWTM)
Principal Investigator: Dr. Saumyen Guha, Indian Inst. of Technology, Kanpur, India
Swedish Resource Person: Prof. Erik Särner, 2001–2005, and Prof. Jes la cour Jansen, from 2006, both at Lund University, Lund, Sweden.
Team Leader: Dr. C.S. Harendranath, Indian Inst. of Technology, Mumbai, India
Team Leader: Dr. Nguyen Trung Viet, Vanlang University, Ho Chi Minh, Vietnam
Team Leader: Dr. Piyabutr Wanichpongpan, King Mongkut Univ., Bangkok, Thailand
Team Leader: Prof. Ajit P. Annachhatre, AIT, Bangkok, Thailand

Sustainable Solid Waste Landfill Management in Asia (SWLF)
Principal Investigator: Prof. C. Visvanathan, AIT, Bangkok
Swedish Resource Person: Prof. William Hogland, Univ. of Kalmar, Sweden
Team Leader: Dr. Zhou Gongming, Tongji Univ., Shanghai, China
Team Leader: Dr. Chart Chiemchaisri, Kasetsart Univ, Bangkok, Thailand
Team Leader: Dr. Kurian Joseph, Anna Univ., Chennai, India
Team Leader: Dr. B F A Basnayake, Univ. of Peradeniya, Peradeniya, Sri Lanka

Improving Air Quality in Asian developing Countries (AIRPET)
Principal Investigator: Dr. Nguyen Thi Kim Oanh, AIT, Bangkok, Thailand
Co-Principal Investigator: Prof. Chongrak Polprasert, AIT, Bangkok, Thailand
Swedish Resource Person: Prof. Eva Selin Lindgren, Borås University, Sweden
Team Leader: Prof. Hao Zhen Ping, Res. Centre for Eco-Env., Beijing, China
Team Leader: Dr. James Simpas, Manila Observatory, Quezon City, Philippines
Team Leader: Dr. Ligy Philip, Indian Inst. of Technology, Chennai, India
Team Leader: Dr. Ir. Puji Lestari, Inst. Technology Bandung, Bandung, Indonesia
Team Leader: Dr. Hoang Xuan Co, Hanoi Univ, of Science, Hanoi, Vietnam

Industrial and Hazardous Waste Treatment and Management (IHWTM)
Principal Investigator: Prof. Ajit P. Annachhatre, AIT, Bangkok, Thailand
Swedish Resource Person: Prof. Bo Mattiasson, Lund University, Sweden
Team Leader: Dr. D. R. Ranade, Agharkar Res. Inst., Pune, India
Team Leader: Ms. Wieke Pratiwi, Centre for Pulp & Paper, Bandung Indonesia
Team Leader: Prof. Abu Bakar Mohamed, Universiti Kebangsaan Malaysia, Selangor, Malaysia
Team Leader: Dr. Susan Gallardo, De la Salle University, Manila, Philippines
Team Leader: Dr. M.W Jayaweera, Univ of Moratuwa, Moratuwa, Sri Lanka

3.2 Resources

ARRPET I was devoted to laboratory research, ARRPET II to continued laboratory research and in some cases, to scaling up to pilot plant scale.

In Phase I (2001–2003) 24 million SEK and in Phase II (2004–2007) 32 million SEK were allocated to ARRPET (Table 1).

Table 1. Distribution of funds allocated for ARRPET I and II (kSEK). The AIT column includes costs for research carried out at AIT and for AR meetings. From year 2004, it includes a sum for unforeseen that can be used also outside AIT. The column for NRI includes costs for research and regional/national meetings.

	AIT	NRI	RP	ARW	Admin.	Total
2001	1,380	3,760	160	400	300	6,000
2002	2,130	5,830	170	420	450	9,000
2003	2,120	5,810	180	440	450	9,000
2004	2,200	5,164	171	418	447	8,400
2005	2,350	5,200	170	420	460	8,600
2006	2,090	4,700	170	420	420	7,800
2007	1,726	4,500	170	420	384	7,200
Total	13,996	34,964	1,191	2,938	2,911	56,000

Seventy per cent of the total is allocated to the NRI (available for the following seven line items: Minor equipment, Literature, Consumables, Field work, Personals, Regional networking and Unforeseen) and to Swedish resource persons. The remaining thirty per cent is allocated to AIT to cover costs for administration, publications, travel, project costs, salary compensation, etc. At AIT a 10% overhead (OH) is paid, while no OH is paid at the other NRI.

The column for Swedish Resource Persons includes one week salary compensation and travel costs to the annual review meetings (see Annex 4). The column for administration includes costs for program coordination and AIT administration.

A closer look at the distribution of funds of ARRPET II shows the allocations for research and SMA coordination (Table 2a) and total allocations (Table 2b), including RP and overall coordination, including AR meetings. Differing amounts of research money to different NRI in the yearly allocations (Table 2a) is due to different agreements based on the application for funds made by each NRI to the coordinator at AIT. The allocations were finally decided by the coordinator in agreement with the resource person of each Subject Matter Area.

The distribution of allocations in ARRPET II is essentially according to the budget proposed in the Sida memorandum in 2003 (Table 3).

Table 2a. Distribution of ARRPET II funds for research activities and SMA coordination.

NRI	2004	2005	2006	2007	Total
WWTM					
RSIC-IITB, India	325,197	327,628	295,461	283,775	1,232,061
IITK, India	325,197	327,628	295,461	283,774	1,232,060
KMUTT, Thailand	325,196	327,627	295,460	283,774	1,232,057
CENTEMA, Vietnam	325,197	327,628	295,460	283,774	1,232,059
AIT, Thailand	317,826	340,303	301,111	244,609	1,203,849
Total	**1,618,613**	**1,650,814**	**1,482,953**	**1,379,706**	**6,132,086**
AIT (coordination)	136,008	144,502	128,522	107,062	516,093
Total	**1,754,621**	**1,795,316**	**1,611,475**	**1,486,768**	**6,648,179**
SWLF					
Tongji University, China	217,762	217,395	197,289	187,501	819,947
Anna University, India	315,755	315,223	286,071	271,876	1,188,925
Univ. Peradeniya, Sri Lanka	283,093	282,614	256,478	243,750	1,065,935
Kasetsart University, Thailand	272,196	271,746	246,612	234,378	1,024,932
AIT, Thailand	294,333	314,672	278,922	227,615	1,115,542
Total	**1,383,139**	**1,401,650**	**1,265,372**	**1,165,120**	**5,215,281**
AIT*	141,500	150,934	133,639	110,056	536,129

NRI	2004	2005	2006	2007	Total
Total	**1,542,639**	**1,572,584**	**1,399,011**	**1,275,176**	**5,751,410**
AIRPET					
RCES, China	318,160	325,624	295,756	278,460	1,218,000
IIT, India	239,010	244,620	222,182	209,188	915,000
ITB, Indonesia	318,160	325,624	295,756	278,460	1,218,000
MO, Philippines	239,012	244,619	222,181	209,188	915,000
HU, Vietnam	362,198	370,697	336,695	317,003	1,386,593
AIT, Thailand	342,693	367,347	325,039	266,242	1,301,320
Total	**1,819,233**	**1,878,531**	**1,697,609**	**1,558,541**	**6,953,913**
AIT (coordination)	167,867	179,059	158,542	130,564	6,360,031
TotaL	**1,987,100**	**2,057,589**	**1,856,151**	**1,689,104**	**7,589,944**
IHWTM					
ARI, India	352,548	355,936	319,594	306,332	1,334,410
CPP, Indonesia	312,325	314,165	282,464	270,751	1,179,705
UKM, Malaysia	265,601	265,645	239,335	229,419	1,000,000
DLSU, Philippines	352,549	355,936	319,594	306,332	1,334,411
UoM, Sri Lanka	278,602	279,145	251,335	240,918	1,050,000
AIT, Thailand	344,839	369,923	326,738	266,649	1,308,149
Total	**1,906,464**	**1,940,750**	**1,739,060**	**1,620,401**	**7,206,675**
AIT (coordination)	146,816	156,283	138,860	115,373	557,332
Total	**2,053,280**	**2,097,033**	**1,877,920**	**1,735,774**	**7,764,007**

Table 2b. Distribution of total ARRPET II allocations (kSEK)

Activities	2004	2005	2006	2007	Total
I. NRI Research Activities	5,428	5,479	4,953	4,719	20,579
II. AIT Activities					
1) AIT Research Activities (4 projects)	1,892	2,023	1,791	1,468	7,175
2) Swedish Resource Persons	171	170	170	170	681
3) Annual Review Workshops	439	443	443	440	1,765
4) Programme Coordination	470	485	443	403	1,800
Total AIT Activities	2,972	3,120	2,847	2,481	11,421
Total	**8,400**	**8,600**	**7,800**	**7,200**	**32,000**

Table 3. ARRPET II budget as proposed in the Sida memorandum in 2003 (kSEK)

Activities	2004	2005	2006	2007	Total
NRI Research Activities	5,164	5,200	4,700	4,500	19,564
AIT Research Activities	1,800	1,920	1,700	1,400	6,820
Swedish Resource Persons	171	170	170	170	681
Annual Review Workshops	418	420	420	420	1,678
Programme Coordination	447	460	420	384	1,711
Unforeseen	400	430	390	326	1,546
Total	**8,400**	**8,600**	**7,800**	**7,200**	**32,000**

4. Evaluation of ARRPET

4.1 Evaluation Methodology

The evaluation is based on the following documents

- The objectives as stated in the Sida memorandums on ARRPET I and II (see Section 4.1.1)
- The questions posed in the Sida terms of reference (see Section 4.1.2)
- The Logical Framework Approach (LFA) matrices constructed at Theme and NRI levels (see Section 4.1.3)
- A questionnaire (Annex 2) based on the formulations in the Sida memorandums (see Section 4.1.4)

The answers to the questionnaires circulated to the NRI in each SMA were interpreted by the respective evaluator through i) assessment of the written answers,, complemented by ii) discussions with both the NRI team leader and the associated researchers. The main findings from the evaluator interpretations are in Section 4.5.2–4.5.5, and the conclusions are integrated into Section 5.

4.1.1 Objectives stated in the Sida memorandums

The primary objectives as stated in the Sida memorandums[1] on ARRPET I are:

- To mobilize and strengthen the scientific competence and capacity at the National Research Institutes for conducting research into fields that are relevant for national and regional initiatives for policy plans, controlling urban and environmental pollution.
- To generate good quality research relevant to the Asian region with focus on hard science and technology
- To develop technical solutions to environmental problems and adapt them to the local situation.
- To disseminate the results of the Program among policy makers with an aim to have an impact on policy plans.

The following ARRPET I objectives may be seen as secondary:

- To create links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas.
- To integrate science, technology, financial aspects and policy in the implementation of results.
- To contribute to strategically environment-friendly production in the implementation of results

The primary objectives ("expected results at the program level") as stated in the Sida memorandum[2] on ARRPET II are:

- To develop technical solutions to environmental problems and to adapt them to the local situation (continued from ARRPET I).
- To develop policy recommendations based on such solutions (continued from ARRPET I).
- To strengthen the existing research capacity in the region (continued from ARRPET I).
- To disseminate research results (both on the academic and on the practical/technical level)

4.1.2 Questions posed in the ToR

The specific questions posed in the ToR are:

- To what extent has the program been able to harmonise/influence national research agendas in the region with the global research agenda?

[1] "Idépromemoria 2000-02-07"; "Promemoria 2000-10-12", objectives translated from Swedish
[2] "Promemoria 2003-10-20; Diarienummer 2003-2520", objectives translated from Swedish

- Are there implications of the ARRPET research on the regional debate and practises with regard to environmental technology?
- How can knowledge generated in the program benefit the less developed countries?
- Has the ARRPET program influenced poverty reduction strategies?
- What are the modes of cooperation between different NRI as well as other actors?
- If cooperation with commercial actors has been established, what are the arrangements/mechanism for sharing of development costs and benefits (intellectual property rights). Is there an innovation concept and how relevant is it to the program?
- How was the NRI identified? What is the role of AIT versus the NRI? Hub or node? At what level in the organisation are contracts signed? And, have contracts been cancelled due to lack of fulfilment?
- Research administration, internal control in terms of governance, financial and administration routines with the program and the network.
- To what extent are the research activities integrated in the NCI s research agenda?
- To what extent are the laboratories used as pooled resources?
- What is the mechanism for internal charges with regard to laboratory analyses?
- Where is the "ownership" of the program?
- What is the influence/role of the Swedish resource persons involved?
- Has the program created a common agenda (harmonization?) among NRI based on the research agendas with regard to policies, training (curricula development)? If this is the case where is the emphasis on "teaching or research universities", or are there other strategies?
- Is there national financial contribution to the program?
- Are there prospects of acquiring a larger, government, private sector or regional funding?
- Would some part of the research or/and training be more appropriate for the private commercial than the government sector?
- To what extent is there complementary or doubled financing of activities?
- Are there cases where commercial interests have taken over facilities or techniques?
- Has the program been able to capitalise on differences within the network in terms of complementarity and enhancement of the weaker NRI?
- Or, has there been competition for funds among NRI and/or themes?
- Has the program been able to strike an appropriate balance between creation of new knowledge and capacity enhancement?
- What is the relevance to the Asian region of the papers published?

4.1.3 The Logic Framework Approach

At the beginning of the project a Logical Framework Approach (LFA) matrix was made for the program as a whole as well as for each subject matter area. LFA matrices were also added to each of the sub-contracts between AIT and respective NRI. The LFA matrix lists objectives, expected results, activities, assumptions and indicators. The expected results for the program as a whole are:

– Develop technical solutions adapted to local conditions
– Formulate policy recommendations for these solutions
– Strengthen existing research capacity in the region
– Disseminate the research results (academic as well as technical)

It was also foreseen that contacts would be established between ARRPET and another network in South East Asia financed by SAREC, namely Environment and Economy Program for South East Asia

(EEPSEA) coordinated from Singapore. EEPSEA is a network of researchers active in the area of environmental economics.

4.1.4 Other basic evaluation parameters

A number of additional, basic evaluation parameters have been used (detailed in Annex 2). They cover these additional aspects:

- Scientific methodology
- Scientific results
- Feasibility and relevance
- Gender balance and equity
- Scientific capacity strengthening
- Networking
- Support from AIT to NRI
- Achievement of goals
- Dissemination of results
- Implementation of results
- Finance

4.2 The Evaluation Team

Team leader and Co-Evaluator IHWTM: Peter Sundin, Mr, PhD, Associate Professor; International Science Programme, Uppsala University, Uppsala, Sweden

Co-Evaluator IHWTM, and responsible for an initial Fact Finding Mission: Bo Göhl, Mr, PhD; Strängnäs, Sweden

Evaluator SWLF: Cecilia Petersen, Ms, PhD; Swedish Environmental Protection Agency, Stockholm, Sweden

Evaluator WWTM: Cecilia Öman, Ms, PhD, Associate Professor; International Foundation for Science, Stockholm, Sweden

Evaluator AIRPET. Björn Wahlstedt, Mr, MSc; Conexor AB, Bromma, Sweden

4.3 Fact Finding Mission

The Fact Finding mission was lead by Bo Göhl, who carried out all interviews except for those with the resource persons (RP). The RP interviews were handled by Peter Sundin, with Bo Göhl participating in those of the RP for IHWTM and WWTM. In Annex 4 the interviews are summarized, mainly reflecting the views expressed by the persons interviewed, along with some comments. The conclusions of the Fact Finding Mission are integrated into Section 5.

4.4 The Website

The ARRPET program has its own website (http://www.arrpet.ait.ac.th). This website serves mainly to keep network members updated on basic information related to ARRPET – contact addresses, meeting reports, etc. In 2007 it was upgraded to include a database on related literature and scientific reports from outside the program. For reasons of copyright and space, full reports are not generally uploaded. As many teaching institutes and others interested may have poor access to scientific literature, we recommend that more full reports are uploaded on the web. Unfortunately, AIT regulations do not allow the addition of a tracker to the website. This would enable the webmaster to see who visits the site and could thus better target the site. We recommend that ARRPET adds a tracker of a type that cannot be

used improperly. Such public trackers are available free of charge, e g from http://extremetracking.com. Another shortcoming is that there is no link from the main website of AIT (http://www.ait.ac.th), which may make it difficult to find the ARRPET site without the help of a search engine.

As many of the network members also have teaching obligations it would be valuable if the website could be a repository for teaching material such as Power Point presentations, etc. To add a database with best practices, scientific reports, teaching materials, news clippings, etc. would be a very valuable extension and a theme worth pursuing.

In 1978, AIT established a center for information on energy resources. This Regional Energy Resources Information Center (RERIC) collects, repackages, and disseminates information on energy. Over the years, RERIC has established an excellent worldwide reputation for providing information on the latest developments in energy and related topics. It was developed into a website that provides access to materials and information available on energy conservation, renewable sources of energy, energy planning, etc. It is intended both for research and outreach activities. Of late it has been inactive as it was financed by membership fees. The idea is valid for the subject matter areas covered by ARRPET. Access to information is one of the obstacles facing municipalities that wish to solve problems related to solid waste management, air quality, handling of hazardous waste or waste water issues. It could be worthwhile to examine the relation between the RERIC and the ARRPET websites and consider measures to obtain synergy effects.

4.5 The Research Program

The ARRPET website[3] contains comprehensive information of participants, results, publications, training activities and student training. The evaluators' descriptions of the activities within the four SMA are presented in Annex 5. Sections 4.5.2–4.5.5 give summaries and main conclusions. The subsections have been structured slightly differently by the respective evaluators, but the general assessments are summarized in section 5.

4.5.1 General

When the ARRPET program was designed in the 1990's the environment scene in Asia was very different from now. Ordinary people were unaware that environmental degradation was a threat to their livelihood. Their governments prioritised economic growth, and environmental concern was seen as an obstacle to rapid economic expansion. A few influential people realized that the destruction of the biosphere had to be reversed, and universities were preparing to launch departments to address environmental issues. For most people then, emphasis was on visible problems that newspapers had begun to write about – air pollution, pollution of rivers and lakes; collection and disposal of solid waste, etc. Issues such as emission of greenhouse gases, biodiversity, production and consumption patterns, contamination of the biosphere, persistent organic pollutants, etc, were not yet on the table.

It follows that it was only natural that the ARRPET program should focus on degradation of air quality, sewage treatment, solid waste and hazardous industrial waste. While some of the environmental issues that have emerged during the past ten years have become bandwagons where every donor and every university wants to be involved, the four subject matter areas selected for the ARRPET program are certainly relevant even today and address serious and real environmental problems.

Greenhouse gas emission and global warming is probably the most serious environmental threat facing mankind. There are links between the ARRPET program on solid waste management and methane emission, but otherwise there are no other obvious connections to any of the programs. The reduction of the release of methane, which has a 20 times more heat reflective property than carbon dioxide, is a very appropriate way to address global warming issues by a tropical developing country.

[3] http://www.arrpet.ait.ac.th/Evaluation.html

It has been discussed whether ARRPET shall include research on persistent organic pollutants (POP). Sweden was very active in organizing the global ban on production and use of the twelve compounds listed as POP ("The Stockholm Convention"). Global actions on monitoring and cleaning up of POP are coordinated by the POP Secretariat in Geneva (http://www.pops.int) and are financed through the Global Environment Fund (GEF). Funding is very generous for countries that have signed the Multilateral Environmental Agreement on POP. All countries involved in the ARRPET program have ratified the agreement and no production or importation of any POP substance takes place in any of the participating countries outside the frame of the convention. Inventories of remnants of POP have been made in all countries through the POP Secretariat, and remaining problems are addressed through GEF. Most countries have already submitted their National Implementation Plans (NIP) to the Secretariat. In general the problems identified concern PCB in old transformers, illegal use of DDT, and dioxin in contaminated areas in Vietnam sprayed with Agent Orange during the war. Dioxin from open burning of trash is a remaining problem. Apart from this, it is felt that the POP situation is under control and problems are already being addressed in an appropriate manner.

4.5.2 Wastewater treatment and management

This SMA aims at evolving efficient methods and strategies for wastewater treatment and management. Issues regarding domestic and industrial wastewaters are addressed.

The project has two broad themes, namely:

- Treatment and Management of Domestic Wastewater.
- Treatment and Management of Agro-based Industrial Wastewater.

Besides research, SMA also aimed at mobilizing and strengthening the competence of NRI with a view to developing policy guidelines for management of domestic and agro-based industrial wastewaters.

The major issues being addressed in this research include:

- Treatment and management, reuse and recycle in Agro-based industries
- Development of wastewater nitrogen removal processes
- Anaerobic treatment of domestic wastewater
- Development of sustainable practices in Agro-based industries
- Bioremediation and reuse of marine shrimp farm effluent

Research is conducted jointly by the AIT and five NRI from Asian developing countries: India (2), Thailand (2) and Vietnam. Swedish Resource Person (RP) is Prof. Jes la Coer Jensen who took over from Prof. Eric Särner, both of Lund University, in 2006.

Results and Discussion

Scientific Results as Impact Factors of the Journals for WWTM NRI Publications

One way of assessing scientific impact is listing the impact factors of journals of published and in-press papers for the NRI (Table 4). The list may not be complete, but gives a good overview of what has been generated in the project. In addition, several manuscripts will have been submitted to peer-review journals before the ending of ARRPET phase II.

Table 4. Publications in international, refereed scientific journals and their impact factors (IF; NA – not available).

Journal	IF 2006	Number of articles	Impact
Applied Microbiology and Biotechnology	2.441	2	4.882
Bioresource Technology	2.180	1	2.180
Biotechnology Advances	4.943	1	4.943

Journal	IF 2006	Number of articles	Impact
Biotechnology Bioengineering	2.999	1	2.999
Environment, Development and Sustainability	NA	1	
Environmental Technology	0.528	1	0.528
J. Metals, Materials, Minerals	NA	1	
Rev. Env. Sci. Biotechnology	NA	1	
Wageningen J. Life Sciences	NA	1	
Water Research	2.459	2	4.918
Water Sci Tech.	NA	2	
Total Impact		**14**	**20,450**

The list does not include conference publications, reports and book chapters as they are not routinely awarded an impact factor. Impact factors for 2006 are shown, obtained from the "ISI Web of Knowledge", accessed through Uppsala University Library. A short discussion of the relevance of impact factors is given in Section 5.2.

Definition of scientific capacity

Scientific capacity can be defined either absolutely, in terms of scientific infrastructure and scientific tradition, or in the capacity to do the best research given the limitations of the environment provided. This second definition is the one used by the evaluator.

Conclusions

General

- The overall conclusion is that the WWTM SMA activities as a whole have been very good in terms of networking, scientific publications and pilot-scale research
- As expected, improvements can be made
- Areas which could be jointly addressed in the future, where some NRI would benefit from the competence of others include:
- Publishing
- Large scale research
- Implementation in actual practise
- Networking with end-users
- It seems the NRI are generally content with ARRPET I and II, and willing, and have the capacity to take on a third phase. One main benefit argued for is the network between countries that is not often otherwise accessible.

Scientific methodology

Objectives

- The objectives of the research are defined in the Sida memorandums on ARRPET I in 2000 and on ARRPET II in 2003. However, team leaders and researchers seemed unfamiliar with the content of these documents. For this reason there is some confusion in the groups as to exactly what Sida's expectations are.

Research methods

- Each country has its own set of problems and its own scientific infrastructure. It follows that each NRI must be given the freedom to develop its own research methods which will mirror the needs and actual resources of that NRI. This is a benefit to the project.

- There is general agreement that technology from other continents cannot be immediately transferred and implemented before it is properly researched.
- Quality assurance was not sufficiently addressed.

Scientific results

Publishing

- NRI have published in peer- reviewed journals to different degrees, varying from several publications to none.
- A Newsletter[4] is issued jointly with the IHWTM SMA
- Language difficulties have been an obstacle to international publication of research findings.
- There is enough data generated at all NRI to allow for more publication of results in international peer review journals.
- There has been a significant amount of joint publication but there is room (and data) for more
- Literature reviews have been published by two NRI.

Gender balance

- Gender balance among students is fair, but not among team-leaders and PI; few of these are women

Scientific capacity strengthening

- Scientific capacity in analytical chemistry is not strengthened, as sophisticated equipment for such research is not provided
- The two Swedish RP have been unclear of their role in the project. This has reduced the potential capacity strengthening that could have been achieved by the external resource person
- At some of the NRI, junior researchers do not have the tradition of approaching senior researcher abroad. This meant that information from other researchers working on similar projects was restricted.
- The different approaches to the objectives in terms of scientific publication and implementation contribute to capacity strengthening in the network.

Networking

NRI level

- The NRI encouraged collaboration between students, sometimes from different countries.
- Students at the NRI level gained insight into project management

Subject Matter Area level

- The network meetings are appreciated by the researches as a very good platform for the sharing of results
- The different cultural traditions, language, amount of resources and needs at the country level meant that communication in the network was not always optimal
- There is scope for more joint projects where different NRI share their knowledge and then co-publish. They might publish two papers focusing on different aspects of the same project. They would then each be first author.
- Joint projects would have been more easily developed if the Sida funding provided for NRI researchers to visit other NRI lab scale or pilot scale plants

[4] http://www.arrpet.ait.ac.th/wwtm/WWTM-website/newsletter.htm

- It would benefit the network if the capacity of each NRI was better acknowledged and appreciated. This evaluation finds that NRI all have much to contribute but that the type of contribution varies substantially. If managed well, this variety of capacities can benefit the full network. But at the same time, to develop a good balance and create a trustful atmosphere where all partners feel they appreciated for their capacities is challenging.

Staffing

- PhD students need long-term scholarships. Most of those attached to the ARRPET research projects were MSc students. This meant that turn-over of staff was too high so that much time was spent on introducing new researchers into the project.

Support from AIT to NRI

- It seems that the instructions from Sida were not always clear. For example, the Sida memorandums used when deciding on the project have several differences when compared to the agreement between Sida and AIT posted on the ARRPET web site. It seems that when questions arise at the NRI level it is up to the PI or coordinator to interpret Sida's intentions. Examples where this has caused unnecessary disturbances within the network are; i) can the team leader be replaced by a skilled researcher at Annual Meetings if the team-leader cannot participate herself?; ii) is co-fundraising allowed?; iii) do all projects have to follow classical scientific methods or can a more applied research methodology be allowed?; iv) can an editor be appointed for language revision of manuscripts?
- The criteria for fund allocation from AIT to NRI are not transparent.

Implementation of results

NRIs were unclear about what was expected of them in terms of implementation of results. Was it, for example, scientific publications, pilot-scale implementation or close collaboration with end-users? This confusion has meant unnecessary difficulties and was caused by unclear Sida guidelines. In the WWTM team there were different views on publication versus implementation. Different teams adopted opposite approaches with little or no understanding for choices made by the other.

- Some NRI develop their research on actual needs presented by the society, whereas others relate their starting point to the state-of-art as presented in the scientific literature.
- Some NRI see research for development as research that can be quickly applied to improve things, whereas others are more cautious and prefer to do thorough scientific studies and implement only after several scientific publications
- Contact with end-users has been established to different degrees, often as a result of previous networking. One NRI has implemented a method at four aquatic farms. Two NRI have jointly been given the opportunity to test their process at pilot-scale in a waste water treatment plant. One has built a plant in conjunction with an industry, treating its waste water, one is negotiating for it to replace the less efficient treatment used at the moment; one has initiated discussions with an industry.
- Sometimes a NRI was asked to research a certain issue; implementation was facilitated in such cases

For NRI without established links with end-users it was difficult and time-consuming to find a partner willing to pay for installation costs at the pilot scale level.

- Only a few NRI addressed decision- and policymakers

Finances

Fund allocation

- NRI team leaders were not involved with the allocation of funds between the NRI, which they all seem to be content with. The change they request is to be more involved in how the funds approved to each NRI can be allocated between different budget items

Budget items

- The NRI claims that funds would have been more efficiently used if had been free to reallocate between budget items; maybe to the level of 25% of the total budget.
- The NRI cannot appoint PhD students if they cannot provide a three year scholarship or other type of contract for that person.
- No funds were provided for sophisticated equipment such as GC and HPLC required for the analyses of samples used in some projects, which created some problems. Old and less effective equipment had to be used, which sometimes delayed the results.

Co-funding

- In-kind contributions by the NRI are substantial and seem to about match those of Sida. Sida requested that the NRI contribute facilities, scholarship, sophisticated equipment and arrange to cover the costs for constructing pilot-plants
- Co-funding was provided by industry and by national sources in several cases
- Co-funding options from other international donors were not explored due to i) an assumption that it was not allowed, ii) inexperience in fundraising especially from other countries
- The issue of Intellectual Property Rights (IPR) has not yet been addressed to any extent but should be considered in future collaboration with commercial stakeholders

Recommendations

These recommendations follow-up on some of the conclusions drawn. They are thought of as addressing a possible continuation of the ARRPET project or when considering similar projects.

Scientific methodology

- Establish a common database which is continuously updated with new data from the projects. The database has to be managed by someone and funds for work-hours have to be included in the budget.

Scientific results

Publishing

- Appoint easily accessible language editors for researchers who do not manage English sufficiently well to prepare a manuscript for publication.

Scientific capacity strengthening and gender balance

- During ARRPET I and II some NRI researchers were trained in such a way that they could now take over as team leaders.. The present team-leader preferably stays on as team-leader supervisor. This would make it possible to improve gender balance.
- Providing capacity strengthening in the field of fundraising is a crucial component.

Networking

- Team-building is to be addressed as a separate and challenging issue and not be assumed to happen by itself
- Appoint independent non-technical resource person with professional skills in team-building who would have time to address network communication. This person will start off by acting as facilitator in all international meetings and possibly also as a reference person in national meetings. This person is called upon by any of the NRI members whenever the communication or sharing of information could be improved.

- At joint meetings two topics should be on the agenda and thoroughly discussed, i) new joint projects and how to manage these in actual practice, ii) new joint publications, who to be first author, who to be co-authors and who to be acknowledged in the text
- NRI researchers and PhD students should visit each others pilot and full scale plants in order to better understand and thus strengthen networking, as well as increasing the number of joint projects and joint publications.

Staffing

- Staffing arrangements have to ensure that at least one researcher – a post doc or PhD – can work on the project for its full or at least half its period.

Finance

- Make in-kind contributions visible in budgets and financial reports; this to show that the NRI contribute substantially to overall funding.

Concluding recommendation

- The evaluator recommends a continuation of ARRPET in an ARRPET III. The total budget for ARRPET III could be increased though approaching other international donors, the industry and national funding agencies. The budget could increase by 50–100% to include scholarship for PhD and master student, travels to visit other NRI, purchasing of sophisticated equipment as well as the co-funding with industry of pilot-scale equipment construction.
- The main argument for continuation is: i) network developed, as well as the benefit from ii) implementation on larger scale of smaller scale results, iii) dissemination of not yet published but achieved results.
- A higher flexibility with regard to line items, as well as funding to support PhD students, would increase the possibility of using funds more effectively.

4.5.3 Sustainable solid waste landfill management in Asia

The mission of the SMA is to enhance solid waste disposal practices and landfill technology for efficient and effective solid waste management in the region.

The objectives are:

- Identifying the existing solid waste management practices
- Development of technically feasible solutions related to sustainable landfill design and operation
- Identifications of policy and institutional limitations and flaws in sustainable waste landfill management in Asia.

Besides this, the researchers in the Subject Matter Area have also set objectives for developing networks and networking skills, in order to mobilize and strengthen the scientific capacity among the NRI.

Research is conducted jointly by AIT and four NRI in China, India, Thailand, and Sri Lanka. Swedish RP is Professor William Hogland of the University of Kalmar.

Solid waste is not only acknowledged by government and municipal officers in many Asian countries as the most pressing environmental problem, it also particularly affects the poor. Most garbage is generated by the well-off. It is collected, and then dumped somewhere else. In Manila in the Philippines, solid waste accounts for about 60% of all waste. This waste from the affluent provides destitute scavengers or waste pickers with a livelihood. Outside Manila, the Payatas dump site alone supports some 60,000 people. Many of them were born and spend their entire lives on the dump. A further 150,000 people, all of them poor, live so near the dumps that they are directly affected by the smell and unhygienic

conditions. The other 40% of waste is not collected because the people are too poor to pay for waste collection. The situation is similar in other Asian countries.

Dump sites are often in or near slum areas. The residents are the first to be affected by potentially toxic leachates, by polluted ground water and by disease.. A frightening example is the outbreak of pneumonic plague in India 1994 traced to the Surat City open waste dump. Crowding and poor sanitation in the surrounding slum area provided ideal conditions for the spread of the disease. In some areas, untreated hospital and health clinic waste is dumped with the rest and then sorted through by poor scavengers.

Results

The group has set up activities based on the technical objectives of the program. In Phase I, landfill was identified as the most important waste disposal technology for Asian developing countries. Literature reviews and laboratory-scale research was carried out on these topics at all NRI. Developing networking skills was also given a lot of attention during Phase I.

In Phase II most of the research results from Phase I were tested in pilot or field scale trials. The general hypothesis was that the characteristics of solid waste in developing countries (e.g. high content of organics) and the environmental and socio-economic conditions in the region results in unique requirements for solid waste and landfill management.

Much of the initial research was therefore carried out in order to characterise the waste and the conditions for waste management (descriptive). The findings were used to develop waste management techniques special adapted to the local context. Some examples are leachate treatment systems, and methods for pre-treatment to stabilise and minimise the volume of land-filled waste.

All progress within the group is monitored and evaluated in relation to the LFA matrix (www.swlf.ait.ac.th/Proposal/lfamatrix.htm).

Discussion

- As has been pointed out in Section 4.5.2, scientific capacity can be measured in different ways. Either it is the capacity in terms of scientific infrastructure and scientific tradition, or it is the capacity to do the best possible type of research given the specific environment.. The aim of the ARRPET project was to mobilize the available capacity. The NRI in the SWLF SMA had very different starting points and hence different status today when it comes to e.g. scientific infrastructure, education and experience of research staff. However, all NRI have strengthened both their scientific capacity and (local) network drastically compared to before the project started.
- It was stated by Sida, that "the capacity is to conduct research relevant for controlling urban and environmental pollution and in relation to national and regional initiatives and policy plans". Thus Sida both expects scientific research, i.e. publications in peer-reviewed journals, as well as implementation of results. The NRI have addressed these two aspects in different ways: some prioritise publication, others prioritise implementation and/or working with stake holders. This is partially due to the NRI original mission from their "home" organisation. For example, Tongji University, Shanghai, China, is a National Research Centre and has implementation as an expressed objective from the national government. However, within the Solid Waste theme all NRI have managed to fulfil most of their obligations in the ARRPET project. All have participated in joint publications and implementation of some of their research findings on pilot scale.
- The researchers have worked actively to improve networking skills. The cooperation resulting from this has given NRI a chance to come further in research, publish more of their results and establish contacts with end-users and decision makers. The establishment of contacts was partially due to the credibility gained by working within an international network.

- Dissemination of results to other end-users than researchers has been improved by network/networking skills; joint workshops and training programs for e.g. policymakers, inviting journalists to attend workshops.
- Resources to finance PhD students would have given the NRI a better chance to keep staff over long term. The degree earned will give students an incentive to continue to work with waste, and stay in the research team. The research team will not have to spend time training new staff. The Solid Waste NRI have a good reputation in the region and staff trained by them can often find better paid jobs.
- According to the NRI, one of the major benefits of ARRPET has been the possibility for long term projects. Sida's reporting requirements have been seen as a support in planning and monitoring progress. Students and staff have all gained insight into project management – quite apart from the individual research topic. In some cases the culture of planning and monitoring research in a longer perspective has also had beneficial effects on parts of the "home" organisation not directly involved in ARRPET.
- The teams in this Subject Matter Area seem to have been effective in reaching the targets stated in the ARRPET-agreement and the LFA matrix. However, Sida's general policies, e.g. on gender and socio-economic issues, seem not to have been considered much in the network.
- NRI appear to be content with the ARRPET projects. Thanks to the positive experiences gained and the capacity mobilised in Phase I and II,all the NRI are willing and able to take on a possible Phase III. All the Solid Waste NRI have planned projects for Phase III based on their research findings in Phase I and II, and have made contacts with waste managers (stake holders) willing to participate in testing these findings full scale.

Conclusions

Publications

- All NRI have participated in joint publications in international peer-reviewed journals. The distribution of individual publications between NRI is somewhat uneven (se Table 5).
- The PI/TL has promoted joint publication as a way support those with weaker English.
- Literature reviews, state of the art and case studies have been published jointly.

Implementation

Contact with end-users has been established to different degrees, and is often a result of earlier networking with these organisations. Some examples of implementations are:

- China – cooperation with Shanghai Laogang MSW Landfill Plant. Research outcome has been used in planning a sustainable MSW management park. The park has preliminary approval by Shanghai City Investment Group and Shanghai Municipal Appearance & Environmental Sanitation Administrative Bureau. It will include stabilized landfill compartments rehabilitation, material recycling, lands remediation, bioreactor of landfill design and construction.
- India – close collaboration with the Corporation of Chennai for the dumpsite rehabilitation studies. The Central Pollution Control Board has recently sought their association in developing landfill guidelines for the small municipalities and joint development of demonstration projects.
- AIT and Thailand – Dumpsite characterization and toxicity study was carried out at Nonthaburi solid waste disposal site, with the co-operation of Nonthaburi Provincial Administrative Organization. For example, a pilot scale waste separation plant was set-up at Nonthaburi solid waste disposal site for recovery of old plastics from dumpsite for RDF production.
- Sri Lanka –landfill pre-treatment results have been applied in a large scale composting system in Colombo. NRI have also completed feasibility study, EIA, CBA and engineering designs of an engineered landfill for the Western Province. It is now being constructed.

Table 5. Publications Phase I and II: Journals and conference papers. The conference in Chennai was organized by ARRPET's Solid Waste-team, and is therefore presented under a separate heading.

Paper category		Phase I & II					
		China	India	Sri Lanka	Thailand	AIT	Total
International Journal	Individual	1	8	-	5	4	18
	Joint		1 (Th)	2 (AIT)	3		7
				1			
National Journal		13	5	5	3	3	29
conferences		5	21	12	16	26	80
	International conference Chennai	1	3	3	3	1	12
		1					
	Joint- International		1 (AIT)		1 (In)		17
				1		1(SL) 1 (In)	
			1		1(In)		
			2 (AIT)		3		
			1				
		4					
	National	1	12	1	1		15
Books							3
Book Chapters							5

Being part of an international network has helped NRI without earlier established links to end users. The NRI within the Subject Matter Area are now very good at carrying out research and education but not at managing full scale construction projects (should e.g. constructions costs be financed by research budgets?). To take on full scale application of results on their own or as their own project is not within their mandate. Full scale construction is a quite different operation when it comes to investments, time scale, etc.

Staffing

- As PhD students require long term scholarships Master degree students have been used. The quicker turn-over of staff, has mean that too much time is spent introducing new researchers into the project.
- Many ex students from the project are now working with waste management in the region. They often find it natural to contact "their" NRI when they need assistance and this provides an important part of the extended network.
- The gender balance among staff and students is fair. However, the PI and all team leaders are men.

Networking

- Networking within NRI works well. Usually the groups work in the same building, have regular meetings and follow up on research progress and administrative matters.
- Networking between NRI is mainly based on the ARW. Communication between ARW is mostly via e-mail.
- The NRI all agree that networking is the most important component of the ARRPET project. The Solid Waste-NRI are leaders in their field of research in the region.

- The NRI facilitate collaboration between students, sometimes from different countries. Collaboration between and exchange of students between NRI has also occurred.
- Cooperation between NRI on joint publications has helped those with weaker English.
- In the beginning of the project literature reviews were conducted and for example the state of the art report on waste management in Asia was published within the project. The project has also established a common database (all raw data is stored at NRI and AIT) and a common source of references that is continuously updated ("Road map"-CD). The home page is used as a common source of information and is available on CD.
- An area that could be jointly addressed is cooperation with decision- and policymakers, end-users and the media for dissemination and implementation of results. This has to some extent been done within the Solid Waste group, but experiences from individual NRI could be of use for the whole ARRPET project.

Finances

- In many cases pilot scale research was conducted in cooperation with local/regional waste managers. The (informal) agreement was generally that the NRI designed, constructed and carried out research, while the waste manager provided access to the plant/waste and in some cases, equipment for sampling etc.
- Most NRI have been able to finance part of their research via other sources, by spin-off projects and contacts with private companies and authorities. These contacts would in many cases not have been made without the ARRPET project. For example Sri Lanka has recently attained an Endowment Chair for ten years financed by a private company; India has recently been approached by the Central Pollution Control Board (Ministry of Environment & Forest) collaboration on designs of landfills in hilly areas and setting up small scale demonstration facilities; Thailand is monitoring a leachate treatment plant on assignment for a municipality; and China has designed and carried out research at a pilot scale plant operated by the regional waste manager.
- Cost-benefit analysis of pilot or full-scale projects has been done when required.

Recommendations

- Carrying out and publishing initial literature reviews and state-of-the-art reports on relevant topics gives the team a common platform for research. This is advisable also for future projects.
- Maintain the joint resources such as home page, data bases and literature reviews. The home page today contains abundant information. To make it more accessible for those outside the network it should be updated and redundant information cleared away.

Concluding remarks

As Side/SAREC financing aimed at mobilizing NRI capacity, it has been in their own interest to make efficient use of these funds. To a large extent it has been possible to combine the objectives of ARRPET with the original NRI assignment given by the national/regional governments and/or the organisation to which the NRI belongs. When there have been conflicts or differences in priorities, the network has helped maintain the focus on achieving the objectives set by Sida.

Networks, networking skills, research and publication work well now. To ensure continuing and more permanent t benefit from the resources already invested – especially to see pilot trials and some scaled up implementation – the project should be continued.

Sidas general policies as to gender and socio-economic aspects have not been particularly considered, at least not so far as they are expressed by the researchers at the NRI.

ARRPET's present thinking is to establish cooperation with private companies and authorities in the waste field. Researchers design and carry out measurements of plants and verification of results. The

authorities or companies construct, operate and run the plants (after the initial phase). In this way ARRPET can continue to concentrate on research while Sida can see significant development happening for the cost of a research project. Ultimately, ARRPET wants to link waste research more and more to climate change (effects from waste generation and management)[5].

4.5.4 Improving air quality in Asian developing countries

Background

Four focal issues are addressed in this Subject Matter Area (also referred to as the Air Quality Group or AIRPET):

1. Monitoring for toxic and organic air pollutants;
2. Appropriate air pollution control technologies; and
3. Modeling tools for integrated air quality management.
4. Integrated air quality management for target sources (added with Phase II).

Research is conducted jointly by AIT and five National Research Institutions (NRI) from Asian developing countries, namely China, India, Indonesia, Philippines and Vietnam. The Principal Investigator (PI) is Dr Nguyen Thi Kim Oanh, and the Co-Principal Investigator is Prof. Chongrak Polprasert, both at AIT. The Swedish RP is Prof. Eva Selin Lindgren of Borås University.

A more comprehensive summary of the various activities in AIRPET is found in Appendix 4.

The Air Quality Group demonstrates a rather heterogeneous picture; some NRI are involved in various short and long term projects producing a large number of published articles, while some focus on one or two areas with, so far, nothing published. Some projects have produced results of practical relevance, but very few have been a "scientific break-through".

Generally, the scientific quality is acceptable; the students seem to be roughly on the same level as corresponding students in Sweden. However, they do seem to be strongly dependent on their teachers/supervisors.

Results

Monitoring

Monitoring of toxic air pollutants and particulate matter source apportionment has been carried out in the following areas:

- Particulate Matter (PM) mass concentration and composition;
- Monitoring for other toxic air pollutants;
- Receptor modeling;
- Emission sources characterization and PM source profiles development;
- Exposure monitoring for health effect study; and
- Atmospheric dry deposition fluxes to Earth surface

Monitoring for fine and coarse particles has been conducted continuously in six cities: Bangkok, Beijing, Chennai, Bandung, Manila, and Hanoi. This has created a long-term monitoring record of fine (PM2.5) and coarse (PM10-2.5) particulate matter mass concentration and composition (continued from phase I) to detect the temporal variation. Among the six cities, mass concentrations of PM10 and PM2.5 are highest in Beijing, especially during dust storm periods. PM2.5, which is more toxic, almost always exceeded the WHO 24h PM2.5 guideline of 25 mg/m3 in all the cities during the dry season. During the wet season the frequency of exceeding the guideline was still high in most of the cities.

[5] The PI is already involved in "3R" (Reduce, Reuse, Recycle) research projects financed by ADB, UNEP, UN and AIT

Semi-Volatile Organic Compounds (VOC), measured as Benzene, Toluene, Ethyl benzene and Xylene (BTE), were monitored at road sites in Vietnam (500 samples). The levels of BTEX and PAH were found to be higher at the urban sites, especially the road sites, than at the remote sites.

Two models have been commonly used by all NRI: Chemical Mass Balance (CMB) and Positive Matrix Factorization (PMF) with source profiles mainly from literature. The results showed biomass burning as a major PM source in all the cities; this had been largely overlooked earlier.

Emission characterization was done for the major PM sources identified by receptor modeling. This produced the first comprehensive detail source profiles for major sources in developing countries in Asia. They included not only ionic elements and Black Carbon/Elemental Carbon (BC/EC) and Organic Carbon (OC) species, but also other organic source markers such as Polycyclic Aromatic Hydrocarbons (PAH). The data are useful to improve the receptor modeling results.

The Blood Lead Level (BLL) was measured in about 400 school children in Bandung, Indonesia. The mean value of those measured was 14 mg/dL and 65% had BLL values above 10 mg/dL, which is the WHO standard for children under 12 years of age. This study effectively called for phasing out of leaded gasoline in Indonesia.

The research has not been fully demand-driven, but has rather been dependent on what was already in place.

The measurement sampling techniques have been harmonized (dichotomous impactors for PM2.5 and PM2.5–10). The number of samples varies between the NRI, but the impression is that the sampling has been carried out at reasonably representative sites with a coordinated height over the ground. The sites have been categorized – traffic; industrial; domestic; etc.

Assessment of the particle masses on the filters has been successfully accomplished as well as analyses of the content in black carbon. Coordination of the analyses of the content in black carbon has been satisfactory.

Recently, background monitoring has been emphasized and is now playing an increasingly important role. Background monitoring should be accompanied by trajectory analyses in order to understand the short and long range origin of the sampled air. However, only one NRI in the SMA has the appropriate meteorological and atmospheric dispersion competence. This competence must be developed and applied; the AIRPET group needs to discuss these issues in detail in order to harmonize their view and activities on the topic.

Dispersion modeling

A number of 3D models have been applied – 3-CMAQ (AIT), CAMx (AIT, Vietnam, Philippines), and CHIMERE (AIT) coupling with MM5 (meteorological model). Other types of models such as ISCST (for brick kilns in Vietnam) have also been used. Application of CAMx-MM5 for ozone air quality in Manila is being investigated. Ozone modeling by UAM-V and CAMx-MM5 was done for Hanoi using the emission inventory developed by Vietnam NRI for this purpose. ISCST was used for modeling impacts of brick kiln emission for emission reduction scenarios study.

Receptor modeling

AIT states that new models for "Receptor Modeling" have been developed. The contribution from AIT compared to the NRI during development, and the level of cooperation to utilize the various models is not entirely clear, but, generally, AIT team worked with the NRIs for model selection and application, and provided training.

The concepts of what are the sources and what are the indicators are not clear and should be assessed in detail. The contribution from long range transportation in relation to the various sources is not clear and should also be assessed in detail.

There is a need to develop the understanding of Aerosol Technology and the basis for aerosol formation, transport, transformation and deposition needs to be discussed and analyzed. Here, understanding the fundamental processes is crucial.

Development of flue gas emission control technology

A few lab-scale control technologies were developed during Phase II including the devices for VOC control (China), NOx control (India), and NOx/CO control (Indonesia). Catalysts Pd/Ln-SBA-15 for removal of benzene, toluene and xylene emissions developed in China performed well for the full elimination of benzene at 200 ºC. A multi-plate reactor, which achieved around 80% removal efficiency with bigger size and larger plate spacing to eliminate NOx gas from coal combustion and vehicle exhaust, was developed in Indonesia.

Some applications of control technologies have been installed in cooperation with external parties. Other promising technologies are in the process of finding practical reference sites for testing.

In general there seems to be a gap between the understanding of how the private sector views control technologies and the development of the technologies within AIRPET. A closer cooperation between researchers and industry at an earlier stage would create a more demand-driven situation that would benefit all parties.

Important areas for control technologies, and where a closer cooperation with stakeholders is recommended, are urban planning including traffic planning/emission, vehicle manufacturers, and some industrial processes. A medium-term plan for the research and practical applications in cooperation with the end users is recommended.

Table 6. Publications in international, refereed scientific journals and their impact factors (IF; NA – not available).

Journal	IF 2006	Number of articles	Impact
Atmospheric Chemistry and Physics	4.362	1	4.362
Atmospheric Environment	2.630	20	52.600
Atmospheric Research	1.304	4	5.216
Biomedical and Environmental Sciences	0.748	1	0.748
Catalysis Letters	1.772	1	1.772
Environmental Monitoring and Assessment	0.793	2	1.586
Environmental Science and Technology	4.040	1	4.040
Journal of Chemical Technology & Biotechnology	NA	1	
Journal of Environmental Sciences	NA	1	
Journal of Geophysical Research	2.800	3	8.4
Journal of International Environmental Pollution	NA	1	
Journal of Molecular Catalysis A	NA	1	
Journal Rare Earth	NA	1	
Journal of Science and Technology	NA	1	
J. Air & Waste Manage. Assoc.	0.825	2	1.650
Physical Chemistry	NA	1	
Terrestrial, Atmospheric and Oceanic Sciences	NA	1	
Total Impact		**43**	**80.734**

Networking, Dissemination, and Workshops organized

An intensive networking has been developed consisting of e-mail communications, idea/information exchange over the Internet, and joint publications. The website (www.http.serd.ait.ac.th/airpet) operated by AIT keeps all NRI informed about events and project documents. A couple of workshops, besides the annual regular meetings at AIT, have been organized.

Up to now the AIRPET team has produced more than 40 peer-reviewed journal articles (Table 6) and close to 50 peer-reviewed papers in international conference proceedings and conference presentations. About 20 MSc manuscripts have been prepared from the research results.

Discussion

The evaluation and comments are based on the reviews, discussions, and follow-ups accomplished by the RP and the Evaluator. The evaluation is made against the objectives and expected results for the program. The Compilation of Questionnaires and the discussions with the various people at the NRI, the PI at AIT, and formal reports are the basis for the evaluation and comments (please see Appendix 4).

AIRPET has had a good impact on the research relevant for Asian countries when it comes to monitoring. AIRPET is probably the only effective ambient air quality monitoring network in Asia which keeps a high and QA/QC validated standard. However,

- There are large differences between the NRI. Some have equipment financed from other sources than ARRPET, and receive funds from government, while others depend totally on ARRPET financing..
- Some NRI focus mainly on monitoring while others at the same time move into applications like pilot plants for control equipment. Modeling is ongoing at all NRI on various levels.
- Some NRI actively promote their results to media and decision makers in order to influence the establishment of standards and guidelines, while others are low key focusing on monitoring and (internal) dissemination of data.

This creates an unlucky imbalance in the program; the core "balanced network idea" is not utilized to its full potential. The PI is trying to enable all NRI to fulfil all objectives but due to the different circumstances listed here, this is not yet accomplished. At some NRI, a change in TL-ship has hampered continuity and has contributed to the observed imbalance. Another explanation is that AIRPET has the same major issue (monitoring) as all NRI, as well as those minor issues NRI chose based on their preference and available resources. NRI spend most efforts on the major issue hence most synergy is within this issue. In Phase II the "imbalance" is less than at the start-up of projects in Phase I when most NRI had no relevant research in this SMA. The development pace of the NRI also depends on the national priority, e.g. air pollution is a priority in China, hence there is more support and spin-off projects there.

The modeling (particularly the receptor modeling) in combination with the monitoring has provided very valuable information and sometimes even surprising results about the source of pollution compounds. Here the network functions better since the samples are sometimes sent to AIT and laboratories at other NRI for analyses and comparison. This automatically creates cooperation which benefits the network idea at the same time as QA/QC is improved.

The number of publications varies a lot between the NRI. One extreme is the NRI which has part only in one conference proceeding paper while another published 35 of the 43 scientific papers under AIRPET.

Conclusions and Recommendations

There are two ways to handle the imbalances in the network. One is simply to exclude the low performing NRI (those not fulfilling the objectives and providing the results as agreed) and (perhaps) replace these with others which promise to perform better. The other way is to – in various ways – allocate more resources to supporting those NRI in need of more development. To exclude some NRI in favor

of "new" ones would hardly contribute to an increased success of AIRPET. The long term support to the less resourceful NRI by AIT and from the other more resourceful NRI should rather be seen as one of the goals of ARRPET.

- The NRI show, as mentioned above, a rather heterogeneous picture with different focus and competences. This could be seen as positive, and used to improve the general level of knowledge to a greater extent than has been the case so far.
- There is a need for a more active direct cooperation between the NRI. Joint projects would create such cooperation and one suitable area of research for this increased cooperation could be long range transportation.
- There is only limited interaction and direct learning between the researchers on various levels in AIRPET. This needs to be improved. The reasons may vary, but the result is that the basic idea of the network is not utilized to its full potential.
- The potential for disseminating the often very good and interesting results (from monitoring and emission source characterization) and in this way inform and influence decision- and policymakers, standards and guidelines, as well as the general public via media, is not used to the extent possible.
- Training sessions on how to approach decision- and policymakers should be arranged using practical examples (there are good examples in both ARRPET and AIRPET).
- The pilot projects sometimes show a potential for commercialization. It is today unclear how a process towards commercialization could be accomplished.
- Rotation of the leading roles in certain AIRPET activities would enable a better understanding of this function. Projects of common interest and the chair role during regional workshops and annual meetings are suitable for this training.
- There is sometimes a lack of critical thinking, self criticism, and understanding of fundamental concepts which is manifested in a readiness to adopt "ready-made solutions". Even if these are applicable, AIRPET needs to explain and justify their adoption.

Proposals for a continuation

The results of the first two phases of the monitoring provide the first systematic record on PM levels and composition as well as other toxic gases since 2002, which is useful for assessment of air pollution levels and potential health effects in the cities. A long-term monitoring in the urban areas and at remote sites is still necessary to track the changes in air quality and to reveal the impacts of policy intervention.

The source apportionment study identified the major local sources of PM and their quantitative contributions. However, the contribution of long range transported pollution (fine particle, and gases) is yet to be determined. In particular, fine sulfate particles at a site may be originating from distant SO2 sources. To develop the effective air quality management for reducing the fine particulate air pollution, this long-range transport contribution should be quantified to the extent possible.

Satellite remote sensing is another emerging tool for the large scale air pollution monitoring and to detect the trans-boundary air pollution. This monitoring method would add synoptic information and visualization to ground-based data especially in those Asian developing countries where there is little ground monitoring The satellite images over the region are available only a few times per day, hence simultaneous near-real time monitoring data is required to get data to compare with the satellite based information.

Dispersion modeling activities within this Phase II have focused mainly on ground level ozone with the input data largely based on the available emission data. These are merely top-down crude estimates made a few years ago and may be the main source of model uncertainty. City and country based emission inventories have to be developed to provide information for air quality management and to improve the modeling results.

Modeling should also be performed for particulate matter, including both primary and secondary, to propose relevant management strategies. Furthermore, future research should address regional dispersion of POP through atmospheric pathway.

Demonstration projects aimed at the development of integrated management strategies for highly polluting sources, such as open burning of different biomass types, vehicles, and industries should be conducted to provide a real life showcase of effective air quality management strategies which could be multiplied and sustained.

All results produced in the project should be harmonized and disseminated to local authorities as an input to the decision making process.

In addition, the inclusion of long-range transport in the development of air quality management strategies is of importance regionally. Consideration of the long-range transport air pollution would help to create harmonization in air quality management for the whole region.

For a continuation, e.g. in a phase III, the following changes and improvements should be considered:

- Allocate more resources to low performing NRI to develop their skills and performance. (Excluding less resourceful NRI might destroy the basic idea of supporting development).
- Allocate 10–15% of the budget to PhD and MSc scholarships and short term exchange programs for students (to AIT and/or other NRI).
- Exchange of researchers between the NRI which would improve learning from each other.
- Extend the annual meetings and regular workshops to include a defined training session (like one week) in a particular area and invite several researchers and students from all NRI to attend.
- Allocate a reasonable amount of the budget to training sessions in presenting information to media and decision makers. (This training should probably not be provided by researchers but rather by communication professionals).
- Focus more on applications and pilot project installations in order to demonstrate practical use of AIRPET to the society.
- Set up workshops/conferences for decision makers from the region (not only nationally) and explain about Best Practice projects and how the results can be applied to the establishment of standards and guidelines with the concrete target of improving ambient air quality.
- Define a policy for immaterial rights, patents, and commercial arrangements for pilot scale projects that develop into a commercial product. (This might rather be an issue for AIT in general?)

4.5.5 Industrial and hazardous waste treatment and management

This SMA aims at developing efficient methods and strategies for industrial and hazardous waste treatment and management. The research has two main themes:

- Removal of heavy metals from industrial discharges
- Removal of chlorinated organics from industrial discharges

The aim is to mobilize and strengthen the competence of NRI with a view to developing policy guidelines for management of industrial and hazardous wastes.

The SMA network consists of six NRI, from India, Indonesia, Malaysia, Philippines, Sri Lanka and Thailand. Swedish RP is Professor Bo Mattiasson, Lund University.

Research objectives

Removal of heavy metals from industrial discharges

Several industrial effluents such as acid mine drainage and waste from the synthetic fiber industry contain heavy metals. Since these effluents also contain sulphate as one of the pollutants, innovative re-

search using sulfidogenic processes for removal of heavy metals as inert sulphide precipitates has been the main research issue. Parallel research has involved heavy metal removal through biological processes, phytoremediation, and physico-chemical processes. Plants with high tolerance to heavy metals have been used in research on root filtration and sedimentation.

Removal of chlorinated organic compounds from industrial discharges

Research deals both with control of chlorinated organic compounds from industrial effluents and with persistent organic pollutants (POP). Industrial effluents such as pulp and paper wastewater from mills where chlorine is used for bleaching often contain high amounts of AOX (Adsorbable Organic Halides). Research has been on biological processes (combination of anaerobic and aerobic processes), on biofilm processes and on UV/H2O2 processes.

Results and Discussion

General

When approaching the IHTWM SMA it soon became obvious that the focus is on hazardous compounds in industrial waste water effluents and the possible removal of toxic substances by microbially mediated methods. One NRI studies PCB degradation which is not usually an industrial waste water component, but rather a component of more concentrated hazardous waste Still, the research approach is the same, and it is necessary to dilute the PCB-contaminated material, dispersing the PCB to make it accessible to microbial degradation in a reactor fed with an aqueous phase. The ARRPET concept of industrial and hazardous waste is significantly narrowed down in comparison to what is generally understood in e.g. legislation and international conventions. With regard to methodology, the IHWTM SMA of the ARRPET program is therefore closely related to the WWTM SMA, also focusing on microbial means of water remediation. Actually, common workshops have been held, and a common WWTM and IHWTM newsletter has been distributed (four issues to date) and is available on the ARRPET web pages.

Scientific methodology

All NRI reviewed their area of research in the beginning of Phase I, and two reviews were published. At one NRI, interviews with concerned government authority officials and potential industrial partners were part of the initial preparation.

The objectives at each NRI were recorded in LFA matrixes, which were actively used for follow-up. The use of hypotheses and statistical considerations as a basis for designing experiments varied, but at least some of the NRI made extensive use of statistical methods for results evaluation.

The overall impression is that the research has been well done, and at some of the NRI performed with excellence. Networking and common workshops have been used for mutual, scientific support between the NRI, and resourceful NRI have provided much support. However, AOX has been defined differently at different NRI, due to access to different kind of instrumentation. This has not been followed up by comparative assessment and validation against standard methods.

Scientific results

The research has in many cases resulted in high quality scientific results. The balance between scientific excellence and possibilities for practical implementation is generally satisfactory. Naturally, those NRI with the best resources could devote more time to fundamental studies. The impact on society is not yet clear, but results have been used in discussions with regulators, and may well influence limit values for hazardous substances in industrial effluents and in receiving waters.

Pilot scale trials

Several processes developed under ARRPET are now investigated at pilot scale in cooperation with industry partners.

- Heavy metal removal through biological sulphate reduction process (AIT, Thailand)
- Development of sequential photo-oxidation and biofilm reactor for degradation of POP with focus on polychlorinated biphenyls (DLSU-Philippines)
- Removal of heavy metals by phytoremediation with bioaugmentation and subsequent biogas production (UoM, Sri Lanka)

Another two projects that may be applied in commercial practice are:

- Adsorbable Organic Halides (AOX) discharges from pulp and paper industry by Up-flow Anaerobic Sludge Blanket (UASB) and suspended carrier biofilm (CPP, Indonesia)
- Removal of AOX using biofilm on activated carbon column reactor and using biofilm for removal of heavy metals (UKM, Malaysia)

Feasibility and relevance

The research has provided considerable opportunity for student training as well as development of the skills of the involved researchers, and has generally been feasible in view of the capacity of the participating NRI. The relevance to the Asian region is clear since the starting point has been real life problems due to current industrial practices. The feasibility of results in terms of to what extent it is possible to develop cost-efficient practical applications varies. A general, technical challenge that needs to be addressed is the adaptation of microbiologically based remediation processes that require sufficient retention times in the reactors, to the effluent flow rates from industries producing hazardous waste water. Another question is whether the pulp and paper industry, once challenged with strict regulations concerning AOX in effluents, chooses to adopt methods aiming at AOX removal or prefers to convert to chlorine-free bleaching techniques.

Gender balance and equity

The overall gender balance is fair, exceeding 40% of the underrepresented gender at four of six NRI. With two female Team Leaders, the gender balance at leadership level is 33% of the underrepresented gender, which also is fair considering the small number (six TL). Still, there is obviously room for improvement.

Student involvement at ARW was scarce, but this may have been due mainly to budget restrictions.

Scientific Capacity Strengthening

Generally, the ARRPET-associated research groups at the participating NRI are more or less above what may be considered a critical mass, although a relatively high turn-over of staff and students means the group is sometimes rather small. Networking compensates for this to some extent. A fairly large number of MSc-students have been trained, and some of the groups contain a significant number of technical personnel, which with the TL add to continuity. Some MSc have stayed with the projects, but otherwise these students account for most of the turn-over. Some NRI have registered PhD students. This is beneficial to the ARRPET research work, but as ARRPET funds do not allow for their support PhD students are confined to those NRI which can find other funding.

There are several cases of collaboration outside ARRPET NRI, which also adds to critical mass.

Several researchers have left to take up other positions, which have strengthened capacity on the regional level, usually without significantly hampering capacity at respective NRI.

Networking

The participants are generally happy with networking on the scientific level, and with the RP input. Communication was usually quite free and informal within the research groups. Exchanges with the Swedish RP could have been more frequent, but was limited by resources made available. The largest variation with regard to networking was the level of interaction with authorities (decision- and policy-makers, regulators, locally and nationally). Here some groups had a good dialogue going while others had only infrequent contacts.

Support from AIT to NRI

The participating research groups were in general satisfied with the support from AIT, not only with administration and finance but also with regard to scientific input and coordination. It should be noted that the ARRPET Coordinator at AIT is also the PI of the IHWTM SMA, which adds to the frequency of interaction and support.

Achievement of goals

With regard to the general objectives, defined by Sida/SAREC in the ARRPET I and II memorandum, achievements were generally good. What remains to be achieved to a higher degree is "To disseminate the results of the Program among policy makers with a view to have an impact on policy plans", "To create links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas" and "To contribute to strategically environmental friendly production in the implementation of results". The other objectives have essentially been met, although "To integrate science, technology, financial aspects and policy in the implementation of results" still lacks much of the policy aspect in the cases where implementation is under way by scaling up to pilot level.

Dissemination of results

The publication of results in international, peer-reviewed journals (Table 7) is lagging behind at some NRI, despite apparently publishable results, but in general the publication rate is satisfactory.

Table 7. Publication in international, refereed scientific journals and their impact factors (IF; NA – not available).

Journal	IF 2006	Number of articles	Impact
Asean Journal of Chemical Engineering		1	
Bioresource Technology	2.180	2	4.360
Biotechnology Advances	4.943	1	4,943
Chemosphere	2.442	1	2.442
Developments in Chemical Engineering and Mineral Processing	NA	1	
Environmental Technology	0.528	1	0.528
Journal of Applied Sciences	NA	1	
Journal of Environmental Management	1.447	1	1.447
Journal of Environmental Sciences and Health A	NA	2	
Journal of Research in Science, Computing and Engineering	NA	1	
Journal of Research in Science and Technology	NA	1	
Process Biochemistry	2.008	1	2.008
Water Environ. Research	NA	1	
Water Science and Technology	NA	2	
Total Impact		**17**	**15.728**

Besides international publication, though, a substantial number of papers have been published in regional and local paper and conference and network proceedings, as well as ARRPET newsletters and manuals addressed to technicians and students.

There are examples of joint publications between NRI, but this possibility could be explored more extensively.

Outreaching activities directed at the public are scarce, but there are examples of e.g. radio communication. Concerned authorities have been approached to various extents and at various levels.
There have been seminars directed at authority staff, and there are cases where NRI participants have been engaged as advisors and government committee members.

Seminars and workshops of the scientific kind have been arranged to a quite satisfactory degree, covering both training with regard to techniques and methods, and communication and discussion of results.

Implementation of results

Full implementation still remains, but at three of the NRI pilot installations are tested with industry, and there is a substantial spin-off project in the area of phytoremediation. The PCB sanitation study has received quite some attention, and future implementation may be possible.

Finance

It is not clear to the team leaders how the funds have been divided between the participating NRI, but each TL has provided the Coordinator at AIT with a proposed budget for the planned research.
The decision has then been made by the coordinator in consultation with the Swedish RP. No TL at any NRI has expressed any concern about the division of money, and AIT has not been tardy in making funds available to the NRI.

The ARRPET funding has been a substantial contribution to the NRI, without which the targeted research would not have been possible, or not possible to the degree carried out.. However, it is quite evident that the contribution "in kind" from the own University/institute has been substantial, making up at least 50% of the total resources available (including salaries, rent and scientific infrastructure). In at least one case the own institute has invested in heavy instrumentation, without which successful participation would not have been possible, in total making up for almost 80% of the total resources handled. Without these contributions the ARRPET program would not have been possible. At the same time, the research would not have been possible without ARRPET funding.

For the future, pilot plants and possible implementation will have to be supported by industry, like it already is on the pilot level. However, to keep the research potential and to be able to extend dissemination to a level where policy influence may be achieved, external support of a more independent kind is necessary. Without such support the scientific progress will fail or be significantly hindered – with negative consequences both to policy influence and introduction of environmentally favourable technology.

Not being allowed to fund students was pointed out as a weakness in the support model, since being able to attract and retain research students would have been important for continuity, especially for the less well off NRI. Likewise, use of the ARRPET funds for some initial investment in equipment at the these NRI would have reinforced scientific quality and sped up research progress. Also, in the perspective of the participating research teams, a closer collaboration with the groups of the Swedish RP would have been desirable, allowing NRI students to be trained in Sweden. Participation of Swedish students contributing to research at the NRI could have been achieved quite cost-effectively, using other sources of support available (e.g. for "Minor Field Studies").

Conclusions

Science

The scientific activities, within the subject areas selected, have generally been of good quality. Some methodological differences with regard to AOX determination, however, are yet unresolved. The focus on microbially mediated remediation of industrial waste waters constitutes a methodological link to the WWTM SMA, and common workshops have been held as well as common newsletters issued.

Feasibility and relevance

The selected activities are generally of high feasibility and regional relevance.

Gender and equity

Gender balance can be improved, but there is not an alarming imbalance, not even at the leadership level. Student participation in results presentation at meetings should be promoted.

Capacity strengthening

Considerable scientific capacity strengthening has been achieved.

Networking

Networking has been very beneficial to the members of the IHWTM SMA research teams, creating a common base that would not have been possible without the ARRPET support.

AIT support

AIT has been supportive to a highly satisfying degree.

Achievement of goals

Goals have been achieved to a satisfactory degree with regard to technical outcome, but not fully when it comes to policy influence and reach-out to the public. Already existing contacts with regulators may to some degree be expected to affect policy in the areas concerned. Earlier contacts with authorities and industry would probably have been useful.

Dissemination

Dissemination of results is generally satisfactory.

Implementation

Several pilot scale installations are running, and additional ones may be set up. Some cases of full scale implementation may result, and a successful spin-off project may be a model for dumpsite remediation, focusing on leachate phytoremediation. In this area, closer contacts with the SWLF SMA are called for.

Finance

Use of funds and handling of the grants has not caused concern, although insight in the decision process has been limited. Being able to use funds for scholarships and instruments would have strengthened the activities especially in those NRI with few resources.

Recommendations

The assessment of the IHWTM SMA gives raise to the following general recommendations.

- More network support to less resourceful NRI, in particular with regard to hypothesis formulation, method validation and dissemination.
- Closer links to industry, in particular with regard to AOX removal.

- More emphasis on outreaching activities and policy influence.
- More student participation in results reporting at meetings.
- Student scholarships made available; The ARRPET program form is ideal for housing a common PhD student school – over the SMA borders. This would have granted better integration between the SMA.
- In continued work, maintain networking benefits in association with the WWTM SMA, and keep the scientific research perspective at pilot and implementation levels.

4.6 Policy Influence

The original documents maintain that involvement of decision- and policymakers in the ARRPET network is important in order to ensure impact at the policy level. It was envisioned that solutions for environmental problems would be developed and that policy recommendations for these solutions would in some way be transferred to decision- and policymakers.

Influence on policy is one of the corner stones of ARRPET, but in the original documents there is only scant discussion of how it should be done. Participants are left to address this important issue without much in the way of guidelines. It is also questionable whether researchers are well placed to have this influence. There has been no systematic attempt to identify decision- and policymakers or seek ways to achieve the desired influence. Influencing policy gains urgency if ARRPET is to enter a third phase.

Nevertheless, staff from various state agencies has been routinely invited to national and regional workshops and the program works with these agencies on harmonization of standards for air and water quality, and waste management. Some members of the ARRPET projects participate in different government committees and advisory panels. There are several examples:

- A member of the air quality project in Vietnam is a member also of the Government Committee on emission standards.
- The air quality project in China participates in the Government Committee on control of volatile compounds.
- In Indonesia a member participates in a committee that drafts legislation on lead in gasoline.
- In Thailand a network member also serves in the Pollution Control Department.
- In Sri Lanka a member works with strategies planning for management of solid waste
- The Team Leader of the IHWTM SMA in Sri Lanka chairs the Central Environmental Authority committee on revision of environmental limit values
- A member in India sits on the Chennai Committee for solid waste management.

This is a start, but closer links with journalists, key government agencies and municipal associations is a must to achieve success in this area. A slightly changed and more accessible website may be an important factor in this work.

4.7 Capacity Strengthening

To strengthen the competence and capacity of participating NRI for environmental research, ARRPET has worked on a broad front:

- A fairly large number of students (MSc and PhD) have been associated with the program for thesis work. In fact most of the research carried out in the different projects has been by students under the supervision of Principal Investigators and Team Leaders.
- NRI with specific skills have organized several training courses where staff from other NRI have been invited. Examples are courses on anaerobic processes, sulphate reduction processes and bio-

mass characterization. It should be noted that funding for training courses was not included in the Sida budget, but is provided free of charge by AIT, and travel costs are shouldered by the NRI's own budget

- Some degree of training on peripheral skills, such as organization of conferences, presentation skills and reporting skills. In some cases, assistance with project design and international publication of results have been provided.
- In the IHWTM SMA, specific training programs for less resourceful NRI have been organized by AIT (e.g. UASB process development and monitoring) or by AIT in cooperation with another NRI (e g a training program on AOX together with Agharkar Research Institute in India).

It should be remembered that scientific research as recently as 20 years ago in some member countries was at a very low level measured by international standards and articles from these countries in international peer reviewed journals very rare. Presentations at international conferences were equally rare and presentation techniques were sub standard. The progress in this respect has been nothing less than remarkable, and several presentations have won awards at international conferences. This applies both to the professional researcher level and to student thesis work. This development demonstrates the value of international exposure in collaborative research programs such as ARRPET.

4.8 Dissemination of Research Results

To disseminate research results, both academic and technical/practical, ARRPET uses several platforms. The most important venue is the workshops. These are of several kinds. The Annual Review Workshop takes place every year and all NRI participate together with the Swedish Resource Persons. Six months later the Regional Workshops takes place where program planning for the different subject matter areas are decided. In addition, each subject matter area organizes one national workshop every year.

Publications in international refereed journals are also part of the ARRPET agreement with the NRI and researchers are encouraged to present their findings at international conferences. A big event was the 2004 International Water Association Conference organized by AIT and where NRI had an opportunity to present their research to 150 international participants. The ARRPET website is playing an increasingly important role in disseminating results.

The industrial linkages of ARRPET also constitute ways by which research results are spread. In cases where the partner is a multinational company (e g Thai Rayon), the influence might be considerable. However, also with smaller industrial partners the influence may be large for the people involved as well as affected.

4.9 Gender Balance

ARRPET was designed as a research program to provide technical solutions to specific environmental problems and gender and poverty aspects did not figure prominently in the pre-project discussions.

In the ARRPET research teams about half of the researchers and students are females. In some projects it is more than half (Philippines and Indonesia) while in some other countries it is less. We find that in general the gender distribution is acceptable, but at the leadership level the female representation is not more than 15–25%, which is far from satisfactory.

4.10 Poverty Issues

If the point of departure had been poverty alleviation alone, ARRPET would most probably have looked differently. This does not preclude that ARRPET has pro-poor benefits. Poor people will most

probably benefit more from a successful outcome than the better-off segment of the population because of the fact that poor now are more exposed to unhealthy environments. Migration to urban centers is very pronounced in Asia. Poor migrants from rural areas move to the mega cities in search of a better life. Usually they end up in the cities' slum areas where infrastructure and services such as waste collection and sewage reticulation are non-existent. Often slum areas are located close to waste dumps or sewage canals. Most mega cities have serious air pollution problems as well and people who live at ground level without access to air conditioning are most affected. There have also been several large-scale scandals related to environmental problems tackled by ARRPET. The Payatas waste dump in Manila and the tributary to Salween poisoned with heavy metals from mine drainage are well documented. It is generally accepted that environmental pollution deepens poverty and impedes development and that ARRPET is mainly in line with the Sida objective of poverty alleviation.

5 Analysis and Conclusions

Sections 5.1–5. accounts for the achievements of the ARRPET program in general terms, while Section 5.4 assesses to what extent the objectives stipulated in the Terms of Reference have been realized, and the achievements with regard to the basic evaluation parameters.

5.1 Quality and Relevance of ARRPET

The creation of ARRPET was timely and the objective to develop technical solutions to environmental problems and adapt these to local situations was, and still is, appropriate. The program„over time, has become more streamlined as "dead end" projects (in the sense that applications would not be feasible) have been phased out. This process should continue allowing greater emphasis on those major topics where implementation is in sight. Where major projects are to be phased out, these could be replaced with one or two of the minor projects that have advanced to such a state that intensified research is justified.

The four subject matter areas were all relevant at the start of ARRPET, and still are today – although emerging issues such as climate change would have been an essential component if the program was to be started today. Adding that perspective in a continuation of the activities could justify an effort to increase collaboration between the subject matter areas. It was noted, though, that the IHWTM theme was focused mainly on hazardous chemicals in waste water, while hazardous waste is more commonly understood to be liquid or solid hazardous waste materials in a concentrated form, e.g. chlorinated solvents, toxic or otherwise hazardous chemicals and mixtures, electronic products waste and other solid waste containing toxic metals and additives. The impression is that the projects selected within the SMA were quite dependent on the research already in place within the groups selected to participate, and not necessarily primarily guided by screening in which areas problems were most urgent and where research would be most needed. Still, depending on the availability of tentative participants, the selection of research areas has been satisfactory. The justification, however, for the project areas selected, however, is not always clear and well documented.

The RP, who are seen as a welcome and influential resource, where engaged at a stage too late to influence the selection of research areas. Although the budget allocated to for their work clearly indicated a limitation in their expected role, their mandate was not clearly spelled out. Hence, they were seen by the participants as their resources, while the primary intention seems to have been as reviewers and advisors to Sida/SAREC.

As the possibility of practical implementation is one of the primary objectives, a closer – and earlier – contact also with potential industrial partners, small companies and other tentative end-users, e.g. environmental authorities, would have been of advantage.

In general, participants are satisfied with how the network has developed and the cooperation with SAREC.

5.2 Impact of ARRPET

It is not yet possible to judge whether all research areas have been successful. Judgment will have to wait until results have been tested under real life conditions. Impact of ARRPET can be seen at other levels than research results per se:

- Co-operation across geographical borders have meant that resources and skills have been pooled, and that dispersed competence has been combined into a stronger and more effective entity
- Researchers have been trained in peripheral skills
- A large number of students have been able to use ARRPET projects for their thesis work, significantly adding to regional competence development.
- Methods used within the network have in many cases been harmonized, and standardized techniques have been adopted
- A large number of scientific publications in refereed international journals testify that research is of good scientific quality. In some cases there is a need for improvement but in other cases focus have been on other issues than scientific excellence.
- Some influence on environmental standards and regulations, and increased awareness among decision- and policymakers is evident.
- Some industries and small scale companies have improved their processes as a result of the research projects

One way to account for scientific impact is to compile the Impact Factors of journals in which a research group or individual scientist publishes. The Impact factor, often abbreviated IF, is a measure of the extent of citations. It is frequently used as a proxy for the importance of a journal to its field. A useful discussion of the relevance to IF can be found at "http://en.wikipedia.org/wiki/Impact_factors". IF have been presented, in a simplified way, for the WWTM, IHWTM and AIRPET SMA. These results indicate that AIRPET may have had a relatively high impact in its scientific field, compared to the two other SMA. But it is clearly seen that most of the AIRPET IF are due to a large number of publications in a single, high IF journal.

With regard to policy impact, it was expressed in the interviews with the RP that effects to some extent can be seen in particular in countries like Indonesia, Sri Lanka, the Philippines and Malaysia, while countries like India and China are too big for much impact to be expected from a relatively small program like ARRPET. In AIRPET, though, the case is more of the reversed. In the Philippines no effects are evident on policy or regulations, while in China AIRPET results have had policy effects in view of air quality connected to the preparations for the coming Olympics.

The web site has of late been upgraded, but is still designed mainly to be used for needs within the network and is still hidden for the average user. It has the potential of being an important outreach tool and some thoughts ought to be given to how this can be accomplished. Impact of a slightly changed web site could be considerable, to fellow researchers, to consultants, to industry and to authorities.

5.3 Network Performance

The network is the most important part of the project. It has allowed research to go further, and the results to spread wider, than would have been possible for individual researchers/single research teams. Even the NRI with more funds available from other sources agree on this. There are, however, examples where networking could have been developed further. The position of the PI of each SMA is very important in facilitating network activities, and a rotating assignment could have assisted in stimulating network function. Also, multiple roles have to a degree hampered exchange of information, in particular during meetings. A participant with more than one key functions can still only be at one place at the same time.

Technically, the ARRPET network has on the whole functioned very well. Administratively it has functioned without any major hiccups and this is a feat in itself considering the complexity and the large number of researchers that are involved. Since its start it has become less centralized and more democratic, a development to be encouraged. Networking success, though, has to a large degree been restricted to within the SMA, and the possibilities to gain advantage by collaboration and networking over the SMA borders has not yet been explored to the full extent, in order to better use to full potential of the network structure. If collaboration continues, ARRPET may thus gain additional strength by intensifying activities among existing members, also between the SMA.

The RP expressed concern that the practice of each NRI to have a major research project and a minor project is not always good. To achieve best impact research should be concentrated on one issue only. On the other hand, the system with major and minor research projects has given the NRI more opportunities to cooperate and support each other on certain issues. This has strengthened the network. In a continued program, however, the concentration on a few items in which several NRI participate and collaborate may be the most advantageous.

Including other, previously left-out countries in the region, such as Laos and Cambodia, as new members could add additional strength both to the existing network, and boost research and much needed activities in environmental science and technology in these countries. It would be important to recognize, however, the increased load on network administration that would result from such an expansion.

5.4 Did ARRPET Reach its Objectives?

5.4.1 Objectives stated in the Sida memorandums

Mobilization and strengthen the scientific competence and capacity at the National Research Institutes for conducting research into fields that are relevant for national and regional initiatives for policy plans, controlling urban and environmental pollution. ARRPET has been successful in mobilizing and strengthening the scientific competence and capacity at most NRI, for conducting research in fields relevant for national and regional initiatives for policy plans, controlling environmental pollution in rural and urban areas. Equally important, ARRPET has initiated systematic environmental research and thinking on a coherent level at the participating laboratories. This makes up a network foundation for action at the policy plan level, once ties to authorities and regulators are strengthened.

The generation of good quality research relevant to the Asian region with focus on hard science and technology. There is no doubt that this objective has been fulfilled to a considerable degree. Within the subject frames given and the agreed limits of use of ARRPET funds good quality research has generally been produced, in most cases in a fruitful combination of scientific excellence and technical applicability. Some needs of improvements have been identified, though, e.g. in the relation between developing and applying models, and with regard to chemical analytical methodology. A more critical attitude could further strengthen the scientific outcome, as well as systematically applying quality assurance measures including intercalibration.

The research projects are relevant to regional environmental challenges, although naturally not fully covering the whole range of addressable topics. Climate change, for instance, has risen as an urgent matter after the inception of the ARRPET program.

The ARRPET network participants, however, have proven ready to take on new challenges, One example is the rapid response to problems concerning waste and waste water management after the tsunami in 2004 (see Box 1 in Annex 4).

The development of technical solutions to environmental problems, and adapting them to the local situation. This has been achieved as a result of several, but not all, studies within the research areas addressed. The technical outcome varies, and ranges from industrial purification techniques to the establishment of regional monitoring programs. With even only one or two large scale applications emanating from the program it should be regarded as very successful. The potential for such breakthroughs are evident.

The dissemination of the results of the Program among policy makers with a view to have an impact on policy plans and The creation of links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas. There are several examples of contacts of the ARRPET researchers with regulators and authorities that can be expected to influence policies e.g. with regard to environmental standards, and guidelines and limit values to industrial discharges. As a good example, results of high blood lead levels in school children became a driving force to phase out the leaded gasoline in Indonesia. Several ARRPET researchers have been engaged as expert members to government committees, even chairing them. With regard to disseminating results to decision- and policymakers and to strengthen environmental protection activities by linking to regional initiatives, however, there are possibilities remaining to be explored.

The integration of science, technology, financial aspects and policy in the implementation of results. This has been achieved to a large degree by exploring the possibilities for application of scientific results by means of Environmental Impact Analysis (EIA) and Cost-Benefit Analysis (CBA), although the policy aspect has not been fully considered.

The contribution to strategically environmental friendly production in the implementation of results. Where results have been implemented, yet only to the pilot stage, the foreseen outcome has been focused at monitoring and remediation, not primarily at environmentally friendly production.

The dissemination of research results (both on the academic and on the practical/technical level). This has in a general sense been satisfactory, but some NRI have not been able to contribute significantly to dissemination. Some NRI have been putting more emphasis on academic dissemination of results, whereas other have prioritised practical and technical solutions. Some NRI suffered lack in language skills and have enjoyed little support in co-authoring from network partners, whereas others had weak network established with end-users and had little experiences from communicating with those.

5.4.2 Questions posed in the ToR

To what extent has the program been able to harmonise/influence national research agendas in the region with the global research agenda? There are no obvious signs that national research agendas have been influenced or harmonised with the global research agenda because of the ARRPET program. However, in some countries ARRPET NRI are the only ones conducting research in their respective area and can therefore to some extent set the agenda.

Are there implications of the ARRPET research on the regional debate and practises with regard to environmental technology? Yes, there are examples of ARRPET research outcomes having influenced regionally. It is not clear if public debate has been influenced, but influence on practises is likely to develop.

How can knowledge generated in the program benefit the less developed countries? By inviting researchers and authority representatives from such countries to workshops and demonstrations, and by providing funds for exchange of researchers and students. Some NRI have already planned for this in a possible Phase III.

Has the ARRPET program influenced poverty reductions strategies? Such strategic influence has not been recorded, but environmental technology development has a general potential to involve poverty reduction aspects.

What are the modes of cooperation between different NRI as well as other actors? There are several modes of cooperation. Scientific, with researchers within the ARRPET network as well as with researchers outside the ARRPET NRI; technical, with industry, in developing pilot applications; and on an expertise level, with authorities and regulators. However, due to lack of travel funds, visits between NRI have been rather scarce. Such visits, if more frequent, could have increased significantly the outcome of ARRPET II.

If cooperation with commercial actors has been made, what are the arrangements/ mechanism for sharing of development costs and benefits (intellectual property rights)? Is there an innovation concept and how relevant is it to the program? Where pilot plants have been constructed the industrial partner is usually providing space, electrical power and materials, while the NRI is contributing with knowledge and maintenance. There is an innovation concept in the adaption of scientific results to practical applications feasible for commercial use. This is relevant to the program, as stated in the primary objectives. *Intellectual propriety rights seem not to have been discussed to a larger extent, but should be prioritised to a higher degree if the project is prolonged.*

How was the NRI identified? What is the role of AIT versus the NRI? Hub or node? At what level in the organisation are contracts signed? And, have contracts been cancelled due to lack of fulfilment? The NRI were selected primarily by using the AIT network of research contacts and alumni, but where contacts were not well enough developed several universities where approach and invited to apply for participation. The role of AIT has been as an administrative hub and a scientific node. Contracts have been signed at the NRI level, that is, between AIT and the NRI directly. Contracts have not been cancelled "mid-term" due to lack of fulfilment. In those few cases they have instead rather not been renewed in the transition between ARRPET phase I and II, because of failures to deliver according to the agreement in Phase I.

Research administration, internal control in terms of governance, financial and administration routines with the program and the network. The general administration has been handled by the Coordinator at AIT, and research administration by the groups of PI and TL of each SMA. Internal control routines practised at each NRI has been followed, and financial and scientific reporting to AIT according to the routines required by Sida/SAREC.

To what extent are the research activities integrated in the NRI's research agenda? Integration varies, but most research activities had their starting point in what respective NRI could offer. In addition to that, there is in most cases an influence of the ARRPET research activities on the development of the research agenda at each NRI. There are also examples on how the research agenda was set in a way that was less relevant for actual practices. For example, household waste water can be treated in a pilot-scale plant only for a short period, as the waste water treatment plant is constructed for mixed municipal waste water and this cannot be easily modified.

To what extent are the laboratories used as pooled resources? To a modest extent, but within the SMA there has been some exchange where advantage has been taken of other NRI's laboratory resources. In the waste waster SMA the two NRI from India are pooling laboratory resources.

What is the mechanism for internal charges with regard to laboratory analyses? Internal charging systems for laboratory analyses differ between NRI, and there are no ARRPET-specific internal charging systems at the NRI.

Where is the ownership of the program? The ownership is at the NRI level.

What is the influence/role of the Swedish resource persons involved? The RP had considerable influence, in particular on the functional level and in particular in the transition between ARRPET I and II. The influence has been proportional to the time spent, and as all RP has spent more time than they were paid for, their influence has been higher than could be expected from their budget. However, they had little say on the general design of the project, including the choice of NRI and on which studies to focus in ARRPET I, since this was already decided when the RP were engaged. The Swedish resource persons did not have clear guidelines for their expected contribution and mandate.

Has the program created a common agenda (harmonization?) among NRI based on the research agendas with regard to policies, training (curricula development)? If this is the case where is the emphasis on "teaching or research Universities", or are there other strategies? No documented common agenda has been created on the policy and training level. But ARRPET has initiated systematic environmental research and thinking on a coherent level at the participating laboratories.

Is there national financial contribution to the program? There is generally no national financial contribution as such to the program, although national funding was available to an extent in some cases. However, contribution "in kind" has been substantial at the NRI level, accounting for 50–80% of the resources available. The NRI contribute with researchers, other staff and the infrastructure at hand, promoting ownership. This, however, is unfortunately not stated at all on the ARRPET website nor elsewhere.

Are there prospects of acquiring a larger, government, private sector or regional funding? This is unknown, as the issue have not been raised within the program. There has, however, been confusion among some of the researchers whether it was allowed to raise additional funds. Also some researchers suffered from little training and experience in how to approach donors. In general, the likelihood of obtaining such support would be higher at NRI being part of a strong network such as ARRPET and where co-operation with the private sector (industries) is based on pilot projects.

Would some part of the research or/and training be more appropriate for the private commercial than the government sector? No, at the current stage there is no part of the research/training that would be more appropriate for the private commercial sector. With regard to those projects that reach an implementation stage, however, it would be advisable to involve commercial actors at an as early stage as possible.

To what extent is there complementary or doubled financing of activities? No cases of complementary or double financing have been recorded; most NRI researchers did not explore the option of applying for additional support.

Are there cases where commercial interests have taken over facilities or techniques? No.

Has the program been able to capitalise on differences within the network in terms of complementarity and enhancement of the weaker NRI? Yes, but to a varying degree within the respective SMA. In many cases less resourceful NRI have been supported by the other NRI in the SMA network, but in certain cases this has not been pursued to much of an extent.

Or, has there been competition for funds among NRI and/or themes? There have been no objections recorded against the division of funds between SMA and NRI, and no obvious competition.

Has the program been able to strike an appropriate balance between creation of new knowledge and capacity enhancement? Yes.

What is the relevance to the Asian region of the papers published? The majority of the papers published is of high relevance to the Asian region.

5.4.3 The Logic Framework Approach

The expected results for the program as a whole as expressed in the LFA matrix can be seen as a summary of the objectives listed in the Sida memorandums, and the outcome will not be repeated here. It can be noted, though, that the foreseen contacts with the Sida/SAREC-supported network Environment and Economy Program for South East Asia (EEPSEA) did not materialise.

5.4.4 Other basic evaluation parameters

Scientific methodology The scientific methods used are generally relevant. The use of hypotheses, systematic experimental design and statistics, however, has not always been optimal.

Scientific results Overall scientific results are satisfactory.

Feasibility and relevance Research and implementation have generally been of high relevance and feasibility, in particularly in Phase II when the focus of the program was improved. The closer activities go to implementation the more important becomes this issue. But, tentative customers (industry/regulators) and RP were not involved in a stage early enough to have an initial influence on feasibility and relevance.

Gender balance There are about 45% females and 55% males involved in the overall programme, which is satisfactory. However at the leadership level the female participation is 15–33%, depending on the group considered, and the balance needs to be improved.

Equity In some SMA there are cases where less resourceful NRI have not been supported to the extent desirable.

Scientific capacity strengthening Generally good to excellent, but common interests and complementary competence could have been linked to a higher extent, in particular between SMA.

Networking Generally good to excellent, it is clear that a networking competence has been developed within ARRPET. However, within SMA the support to less resourceful NRI in some cases could have been more developed. There are different views on cooperation between some of the technically more advanced NRI and those less resourceful, although one of the objectives with the network is to mobilise and strengthen competence and capacity in participating NRI. The approach of using close collaboration for supporting the weaker NRI does not seem to have been utilized to the full extent in all cases.

In some cases scientific publication has been hampered by language difficulties. More attention could have been devoted to this, e.g. in the form of co-authoring, and engaging external assistance.

There are also many common points between the SMA, and also some collaboration over these somewhat artificial borders (in particular between IHWTM and WWTM), but collaboration could have been explored a bit more to the benefit of network strength. This is important to consider in the future.

Support from AIT to NRI In general conceived as good, but the burden of the Coordinator could have been eased by using a formally appointed group to support with management. The Coordinator's several roles decreased his availability, which has notably been the case at the Annual Review Workshop.

At some NRI difficulties with procurement have been experienced. The possibility of utilizing AIT to facilitate this would be an option worth exploring.

Achievement of goals The achievement of the objectives stated in the Sida memorandums is discussed in Section 6.2.1. A summary is given in Table 8.

Table 8. General achievement of goals by ARRPET

Objective	Achievement
To mobilize and strengthen the scientific competence and capacity at the National Research Institutes (…)	Good
To create links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas.	Remains to be fulfilled
To generate good quality research relevant to the Asian region with focus on hard science and technology	Good
To develop technical solutions to environmental problems and to adapt them to the local situation.	Good
To integrate science, technology, financial aspects and policy in the implementation of results.	Good, but policy element not complete
To contribute to strategically environmental friendly production in the implementation of results	Remains to be fulfilled
To disseminate the results of the Program among policy makers with a view to have an impact on policy plans/develop policy recommendations.	Started, but remains to be fulfilled
To disseminate research results (both on the academic and on the practical/technical level)	Good

Dissemination of results Scientific dissemination of results is in general satisfactory, but outreaching activities directed to decision – and policymakers need to be improved, as well as using media to reach out and influence the general public. In a number of cases though, there has been influence of policies, and media contact has been there. In the remaining time of Phase II, however, this is suggested to be intensified.

Implementation of results There are several examples of implementations at the pilot scale, and successful spin-off projects are in progress. It is not likely, however, that all studies have the overall feasibility to permit for full implementation.

Finance The division, distribution and utilization of funds have generally worked well. External co-funding has been scarce, although national funding was available to an extent in some cases. For external funding of research in the selected areas most NRI depended totally of ARRPET, which implies high vulnerability. At the pilot scale level, however, in the cases where implementations already have started, industrial partners are usually involved in funding. Internal co-funding "in kind" has been substantial. PhD scholarships would have improved on quality and continuity.

5.5 Lessons Learned

Sida has been moving away from project financing to budget, sector and program support. Projects are administratively demanding, but can be of great importance in certain circumstances.

- Project support is particularly important to the research sector, where financial support is only one of the components required to establish a fertile research environment. Exposure to the international scene and exchange of experiences with colleagues from other backgrounds is equally important. The fact that funding by a foreign donor brings acceptance and moral support can be of great value to a researcher who feels isolated in his home university.
- Regional networks can be a cost effective and administratively less demanding form of support to research in developing countries. An important aspect of regional research networks is the possibility to create a critical mass of otherwise dispersed and isolated competence. A network that has succeeded in achieving a critical mass level has greater chance to influence policy, introduce new technologies and attract funding. A network that includes participants from advanced research institutions in industrialized countries will bring local recognition to other members of the network.
- Successful networks are almost always formed around a dynamic environment with a group of dedicated people who can unselfishly work beyond the call of duty to assist colleagues that have to do re-

search under difficult conditions. A network functions best if members are in some respects like-minded. It may e.g. be regarding their view on research and development, as appears to be the case in ARRPET. A successful network requires, of course, also a knowledgeable donor who understands the conditions for research in developing countries and who is sympathetic to capacity strengthening of participating institutions. For a dynamic climate to develop open and effortless external and internal communication is a must.

- Support from a foreign donor will in some respect give more status and recognition that in turn will attract more students, increase chances for local funding and having the ear of local authorities. he effect can thus be catalytic with effects beyond the original intentions.
- It is essential that network members seriously consider co-financing of their activities. This is especially true for projects that will lead to practical implementation and where pilot scale plants will be the link between research and practice. For such projects it is essential that a customer is identified at the conceptual stage and that the research is done in close cooperation with the customer who then will be expected to finance a pilot plant and adopt the results in its regular work. To sell an idea that "is not invented here" is an uphill task that in most cases will fail.

6 Recommendations

- It would be extremely valuable to continue to take advantage of the structure, knowledge and competence that has been developed within ARRPET – both in terms of research and technology achievements and in terms of maintaining the functioning network – by facilitating and supporting future work. A lot has been achieved thanks to the years of Sida/SAREC support – not only scientifically and financially but also in guidance and monitoring.
- A third phase would need to be allowed four to five years of implementation and be based on experiences and lessons learned during the first and second phase. As an input to possible, future development, the following changes and amendments are suggested to be considered.
- If such a third phase could be allocated an increased budget, this would most likely significantly increase the expected positive outcome.

6.1 Recommendations to Sida/SAREC

1. Amending the objectives. With a continued support, ARRPET should be requested to review its objectives in order to keep activities in line with emerging needs on the environmental arena, such as concern about global warming and climate change. Already now, several ARRPET activities are of importance for climate change-related factors, and these aspects of activities should be lifted up, emphasized and further developed.

With a continued support, it might be useful to involve social sciences, e.g. to account for socio-economical implications of possible implementations.

2. Support to scaling-up. Ways and means to assist scaling up of research for commercial implementation should be explored. SAREC ought to assist AIT in finding ways to finance pilot scale activities. There are earlier examples of cooperation between SAREC and the Department for Environment and Natural Resources Management (NATUR), where SAREC had responsibility for research activities and NATUR for development work. This issue ought to be examined by the two departments.

Pilot scale activities must be long term with clear strategy and objectives. If SAREC agrees to fund selected pilot-scale activities it should be restricted to cases where an industry, a municipality, or another

end-user bears the brunt of the expenses, shows genuine interest of full-scale implementation, and enters into a formal agreement committing the support. For this to happen in actual practise the researcher need support in terms of funds, time and professional guidance on how to approach the end-user. A research potential should also be at hand in the scaling-up process. If support to a phase III is considered, ARRPET contacts with potential end-users should be given high priority.

3. Establishment of an open fund. Time between the phases is long and the scene changes fast. To achieve greater flexibility and allow for changes and new activities the Coordinating Committee should have access to a research fund that can be used at the discretion of the Coordinating Committee. This fund should then be used to finance new and emerging issues also outside the core network. The use of such funds should be reported annually to Sida.

4. Scholarships to be funded by SAREC. There would be advantages for ARRPET if scholarships could be provided for doctoral students or post-doctoral fellowships. Master students do not usually stay longer than one year and will during that time need relatively much attention. A doctoral student would stay for about three years and would during that time become conversant with the issues of ARRPET and be able to assist the TL in the work. It could be argued that SAREC, having the objective to finance research activities in the region, exploits the good will of AIT to coordinate those activities, while AIT has a wider mandate to build capacity in the region. To provide a number of PhD scholarships could be seen as a way to balance the interests of the two organizations.

Another argument is that some other programs can offer scholarships, which means that there is a tendency for good students to attach themselves to those programs rather than to ARRPET.

Also, more of support for exchange for shorter period training purposes should be considered. I.e. money set aside for travel grants for researchers and students for exchange visits and training within and outside the network NRI.

5. AIT to assist NRI with procurement when required. In some cases NRI experience considerable delays because their own central purchasing departments are not well functioning. In other cases local agents charge exorbitant prices for essential equipment, spare part, and consumables since they practically hold a local (national) monopoly.. AIT should be given the task to assist the projects in such cases by purchasing such items.

6. More effective use of Resource Persons. The overall view, both from ARRPET participants and from the Resource Persons themselves, is that the RP have been quite influential in their function as external reviewers. However, clearer guidelines for their mandate would have been helpful, although the limited budget for their participation nominally set the limits for their engagement. Still, more actively involved resource persons would probably have benefited the development of research activities. Sida/SAREC could consider such an approach in a continuation of ARRPET, or in other programs, backed by appropriate funding.

7. Improved reporting to SAREC. The reports from ARRPET are now voluminous and detailed. Research is described in a scientific language that is difficult for a non-professional to understand. It is a heavy burden for the NRI and AIT to produce these reports and it is time consuming for SAREC to absorb them. The reports detail the research but mention little about problems encountered and how the network operates.

With the results-based monitoring system of Sida, much of the information provided is not essential, while required information can not be found in the reports. AIT and SAREC are recommended to agree on a new and more appropriate reporting format with more generic information that can be useful both in monitoring of ARRPET and useful to SAREC's work in other countries.

8. Application of the ARRPET approach in Africa

The application of a similar approach in an African (south of Sahara) context could be successful if a number of prerequisites are fulfilled.

- The initiative must be truly demand driven building on "win-win" collaboration with local partners
- Acceptance at higher political levels would be necessary, as well as their involvement in planning.
- The approach should be interdisciplinary, involving social sciences.
- Potential end-users should be consulted at an early stage.
- The use of resource persons should be extended to research cooperation.
- An institution corresponding to AIT would need to be identified, with knowledgeable, resourceful and strong leadership.
- A capacity building element should be considered where necessary.
- Scholarships to PhD students should be included, maybe organized as a research school.

6.2 Recommendations to ARRPET

1. Concentration on a few major issues. A phase three will focus on application on research results and research related to application of results. Research issues where no partner for implementation is in sight should be suspended as remaining project time is too short, but making sure that the results are disseminated in refereed scientific journals. To motivate Sida/SAREC support in a phase where scaling up will be an issue of increasing importance, keeping the research potential in the scaling-up work would be an important aspect.

2. Increased cooperation between themes. Co-operation between NRI occur now naturally when there is a need to share expensive equipment or learn new laboratory techniques. There is little co-operation between the NRI concerning scaling-up, policy influence, media communication training, dissemination of research results or commercialization. In a Phase III there is a need for exchange of experiences between the NRI on these subjects and in some cases synergistic effects of combined activities and campaigns. Such campaigns could be designed to more holistically address emerging issues of concern, such as climate change.

3. Increasing publication output. ARRPET participants are recommended to more actively work on publishing results, and whenever called for consider the possibility of producing joint publications with two or more NRI as authors. Where language difficulties are apparent, the appointment of easy accessible language editors should be considered.

4. Developing fundraising and marketing skills. Efforts to increase the impact of ARRPET research and results should be increased by training in contacts with media as well as with decision- and policymakers, and authorities in general. In addition, offering courses and seminars directed at industry, consultants and authorities is an option worth exploring. There is also a need to increase the skills in fundraising.

5. Establishment of a Coordinating Committee and establishing routines for rotating leadership. The Coordinator and the Principal Investigators located at AIT now form an unofficial Coordinating Committee. This is some way a practical arrangement as meetings are easily arranged and daily communication can take place. On the other hand it means concentration of decision power that is not commensurate with a democratic network. There are several options to address this problem – more direct communication between the resource persons and the NRI, outside facilitators at administrative and scientific meetings or the establishment of a formal Coordinating Committee with participation from the NRI. The network should find a suitable mode of work that will satisfy all parties.

In addition, a more active rotation of the leading roles (PI, TL) would train the NRI in this respect.

Also projects of common interest and the chair role during regional workshops and annual meetings are suitable for this training.

6. Rotation of Annual Review Meeting venues. The Annual Review Meetings are now held at the AIT campus in Thailand. The meetings should rotate between the NRI, Furthermore, the Annual Review Meetings could benefit from being combined with e.g. site visits to pilot and implementation plants, and specific training courses (such as media communication).

7. Students to participate in Annual Meetings. Students from the participating projects should be invited and funded to attend. In this way training opportunities are captured at little extra costs. In connection with Annual Review Meetings, common seminars, training courses or workshops could be held, in order to reinforce the common frame of reference.

8. ARRPET launched as a knowledge hub. Prospective users of environmental technologies are often dispersed in local municipalities far removed from scientific literature and university meetings. When they have to decide on an investment on e g a new waste management or waste water treatment system they often even do not know where knowledge is available. There are few places where independent advice can be obtained. Within ARRPET such expertise often can be found. ARRPET knowledge should be publicized to meet this local demand.

Furthermore, it would be valuable if the website could be a repository for teaching material such as Power Point presentations. To add a database with best practices, scientific reports, teaching materials, news clippings, etc. would be a very valuable extension and a theme worth pursuing.

9. Harmonization of nomenclature. This is a minor issue, but there is some confusion with regard to ARRPET nomenclature that should better be avoided. The Subject Matter Areas are in some documents called Themes and Projects. The latter should be avoided, not to confuse the Subject Mater Areas with the projects in operation at each NRI. Furthermore, the Project Leaders at the NRI sometimes refer to themselves as Principal Investigators, which are also the designation of the coordinators of the Subject Matter Areas. This is confusing, not the least to an evaluator.

7 References

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Appendix 1: Terms of Reference

1 Introduction

Asian Regional Research Programme on Environmental Technology (ARRPET) commenced in 2001 with a three years agreement period and a budget of 24 MSEK. The current agreement amounts to 32 msek and will complete its period of four years on December 31, 2007. The program is a network of 18 National Research Institutes (NRI) from 8 countries: China, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and Vietnam.

Out of the budget the lion share (64%) have been, or will be, spent by the NRI activities like data collection and analyses as well as researcher exchange visits between NRI and AIT. Annual meetings account for about 6% and the involvement of Swedish resources persons for 2% and the AIT over head amounts to less than a third (28%).

Research themes and major issues

Information about ARRPET and its activities can be found in the project website: http://www.arrpet.ait.ac.th/

1. Wastewater Treatment and Management
- Treatment and management, reuse and recycle in Agro-based industries
- Development of wastewater nitrogen removal process with methane as electron donor
- Integration of wastewater treatment in ponds with phytoremediation
- Development of sustainable practices in Agro-based industries
- Bioremediation and reuse of marine shrimp farm effluent

2. Sustainable Solid Waste Landfill Management in Asia
- Identification of the phenomena governing the generation of landfill leachate and gas
- Management of landfill emissions and optimizing their treatment methodologies under different parameters
- Pretreatment of MSW, rehabilitation of dumpsites

3. Improving Air Quality in Asian Developing Countries
- Long term monitoring of toxic air pollutants and health effects
- Appropriate control technologies
- Modelling for regional integrated air quality management and forecasting
- Integrated air quality management for target sources

4. Industrial and Hazardous Waste Treatment and Management
- Removal and recovery of heavy metals by biological sulfate reduction and phytoremediation
- Bioremediation of AOX from pulp and paper industrial wastewater
- Biotreatment of persistent organic pollutants (POP)

Principal (development) objectives as stated in the program document 2004–07 are;

"Inappropriate waste water management, improper dumping of solid wastes, unclear air and improper handling of hazardous wastes result in poor public health which further results in decreased productivity, impairment of development and quality-of life improvement schemes, and increased medical costs.

ARRPET aims at increasing awareness of national governments to support policies to protect status by improvement of waste water, management, solid waste disposal, monitoring and controlling air pollution and proper disposal of hazardous wastes. This will lead to alleviation of poverty, improvement of environment and preventive and health measures thus leading to sustainable development in developing countries in Asia."

Immediate objectives (PD 2001, outcome) are;

– Good quality research relevant to the Asian region with focus on hard science and technology
– Mobilise and strengthen the competence and capacity in National Research Institutions (NRI) participating in the Programme for conducting research into national and regional initiatives for policy plan plans, controlling urban and environmental pollution.
– Disseminate the results of the programme among policy makers with a view to have an impact on policy

2 The Scope of the Evaluation

- To what extent has the program been able to harmonise/influence national research agendas in the region with the global research agenda?
- Are there implications of the ARRPET research on the regional debate and practises with regard to environmental technology?
- How can knowledge generated in the program benefit the less developed countries?
- Has the ARRPET program influenced poverty reductions strategies?
- What are the modes of cooperation between different NCIs as well as other actors?
- If cooperation with commercial actors has been made, what are the arrangements/mechanisms for sharing of development costs and benefits (intellectual property rights). Is there an innovation concept and how relevant is it to the program?
- How was the NCI identified? What is the role of AIT versus the NCI? Hub or node? At what level in the organisation are contracts signed? And, have contracts been cancelled due to lack of fulfilment?
- Research administration, internal control in terms of governance, financial and administration routines with the program and the network.
- To what extent are the research activities integrated in the NCI s research agenda?
- To what extent are the laboratories used as pooled resources?
- What is the mechanism for internal charges with regard to laboratory analyses?
- Where is the ownership of the program?
- What is the influence/role of the Swedish resource persons involved?
- Has the program created a common agenda (harmonization?) among NCI based on the research agendas with regard to policies, training (curricula development)? If this is the case where is the emphasis on "teaching or research Universities", or are there other strategies?
- Is there national financial contributions to the program?
- Are there prospects of acquiring a larger, government, private sector or regional funding?
- Would some part of the research or/and training be more appropriate for the private commercial than the government sector?
- To what extent is there complementary or doubled financing of activities?
- Are there cases where commercial interests have taken over facilities or techniques?
- Has the program been able to capitalise on differences within the network in terms of complementarity and enhancement of the weaker NCI?

- Or, has there been competition for funds among NRI and/or themes?
- Has the program been able to strike an appropriate balance between creation of new knowledge and capacity enhancement?
- What is the relevance to the Asian region of the papers published?

The scope of this evaluation is to look at the performance of the "Asian regional research Programme on Environment and Technology" since its commenced in 2001 although the focus will be on the current phase starting in 2004.

The evaluation should also situate the regional program approach within the global context and debate on environmental technology research as a mean to reduce poverty which is the ultimate development objective. To what extent has the program been able to harmonise/ influence national research agendas in the region with the global research agenda? Are there implications of the ARRPET research on the regional debate and practises with regard to environmental technology?

Considering that most of the NRI involved in the cooperation are situated in middle income countries and only Vietnam belong to the focus countries with whom Sida have a bilateral cooperation how can knowledge generated in the program benefit the less developed countries. Assess if the ARRPET program have influenced poverty, or reductions strategies to reduce it, in the countries where the program is executed or in the region. If so, present the links.

The evaluation should also assess the modes of cooperation between different National Collaborating Institutes NCI as well as other actors like commercial companies (if relevant?). If cooperation with commercial actors has been made, assess the arrangements/mechanism for sharing of development costs and benefits (intellectual property rights). Discuss the innovation concept and its relevance for the program.

What is the role of AIT versus the NCI? Hub or node? To what extent are the research activities integrated in the NCI s research agenda? Are laboratories used as pooled resources? What is the mechanism for internal charges with regard to laboratory analyses? Where is the ownership of the program? With regard to the Swedish Resource Persons involved, the evaluation should assess their influence/role on the program.

Has the program created a common agenda (harmonization?) among NCI based on the research agendas with regard to policies, training (curricula development)? If this is the case where is the emphasis on "teaching or research Universities", or are there other strategies?

The evaluation should also assess the national financial contributions to the program as well as the likelihood and prospects of acquiring a, if applicable – larger, government, private sector or regional (i.e. AsDB) funding. With regard to funding the mission should discuss if there are some part of the research or/and training which would be more appropriate for the private commercial than the government sector.

Has the program been able to capitalise on differences within the network in terms of complementarity and enhancement of the weaker NCI? Or, has there been competition for funds among NRI and/or themes? Have the program been able to strike an appropriate balance between creation of new knowledge and capacity enhancement?

With regard to terminology the OECD (2002) definitions of the five evaluations should be used. Briefly, they read as follows:

Effectiveness is the extent to which the development intervention's objectives were achieved, or are expected to be achieved, taking into account their relative importance.

Impact is the positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended.

Relevance is the extent to which the objectives of a development intervention are consistent with beneficiaries' requirements, country needs, global priorities and partners' and donors' policies. Retrospectively, the question of relevance often becomes a question as to whether the objectives of an intervention or its design are still appropriate given changed circumstances.

Sustainability is the continuation of benefit from a development intervention after major development assistance has been completed.

Efficiency is a measure of how economically resources/inputs (funds, expertise, time, etc.) are converted to results.

Research administration, management and facilities

Has the program been able to strike a good balance with regard to internal control and efficiency in distribution of funds, financial and administrative routines in the network.

Research quality (Cutting-edge science)

- Assess research quality in terms of number and quality of papers published (e.g. citation indices) as well as its relevance in the Asian region. Present an overview of journal quality in terms of impacts factors, citations indexes of papers (including self (program) -citation).
- Assess cost effectiveness and efficiency with regard to the use of laboratory equipment, data collection and measurements.

Capacity building

- Assess enhancement of research capacity by the network and/or at the National Research Institutions (NRI).
- Assess the mobilisation and strengthening of the competence and capacity for conducting research in national and regional initiatives for policy plans, controlling urban and environmental pollution (impact).

University influence on development activities

- influence or outcome (impact) on the scope and orientation of the national policies and the national public debates.
- publication strategies in terms of scientific publications, policy briefs, booklets, etc.

3 Methodology, Evaluation Team and Time Schedule

The team leader is responsible for contracting an evaluation team with the composition and competencies covering the four thematic themes in the programme after approval by Sida of the candidates.

Visits and meetings

The mission should visit Asian Institute of Technology (AIT) in Thailand and have meetings with responsible research advisers as well as the AIT management. If possible two Institutes/Universities in each of the four thematic networks should be visited by a team member, thus in total 9 institutes/Universities will be visited. If possible the whole team should travel simultaneously, but in case it is not possible to coordinate the visits more than two separate visits should be avoided.

Division of labor between team members

The team shall be composed of four subject matter specialist and one of the team members will be the team leader and responsible for planning and coordinating of the of the mission.

Reporting

- In connection with the visit at AIT and the network the team should report, preferable in written, preliminary main findings to AIT management and principal advisors.
- The final report shall be written in English and should not exceed 60 pages, excluding annexes, with an abstract of less than 10 pages.
- The outline of the report could follow the Sida Evaluation there is a manual "Looking Back, Moving Forward" to be downloaded from the Sida website. http://www.sida.se/sida/jsp/sida.jsp?d=118&a=3148&searchWords=looking.

Budget

Reimbursables;

- all expenses for travelling to AIT in Bangkok and other relevant institutes in the network with economy class or equivalent (economy plus is allowed at Thai airways)

Fees/time

- 4 weeks per team member and an additional 2 weeks for the team leader

Time schedule

Current agreement ends 31 December 2007 and AIT has asked for a no-cost extension of 8 months to 31 August 2008. Next annual review meeting of ARRPET is scheduled o take place 12–14 November 2007 and this would be a good occasion for the evaluation team to meet several of the members in the network.

Reference documentations and publications

- AIT/ARRPET homepage http://www.ait.ac.th/interimpage/ait_visitor/search/index.asp?q=arrpet&sitesearch=ait.ac.th
- Sida program document

Appendix 2: Structured Interviews and Questionnaire

Structured Interviews

A. Items covered in interviews with Coordinator and AIT Management

Capacity Building

1. Training programs for participants
2. Transfer of knowledge between AIT/NRI and between NRI, exchange of researchers, newsletter, website, training in presentation skills, AIT role
3. Information dissemination. Assistance to members to publish,

Research Activities

1. Selection of projects and their objectives, criteria, emphasis on academic or applied research, conformity with Sida/SAREC objectives, selection process
2. Links with Swedish counterparts, value and quality of contributions from Swedish counterparts (Swedish resource persons?)
3. How are projects monitored and evaluated, other ways to maintain quality
4. Frequency of contacts with project leaders
5. Application of results, pilot scale, commercial scale? Ownership? Influence on society?

Ideas for Improvements

1. How can SAREC support be improved
2. How can networking be improved
3. How can usefulness of research be improved

B. Items covered in interviews with Principal Investigators and Team Leaders

General

1. How and when did respondent get involved in project
2. Selection of research subject: already ongoing or new, who took initiative, who formulated research plan, by whom was the plan vetted, who authorizes changes in plan, objective of project
3. NRI attitude to research and balance between academic and applied research
4. Relation to network: frequency and nature of contacts, reporting, feedback, meetings. Type of support (moral, financial, technical)
5. Complementarily or competition between NRI?
6. Nature of network: Disbursed or centralized, who decides, coordinating committee, how are activities decided, how are funds divided and disbursed
7. Value of network: would the research project materialized without the network, value of moral and technical support, help with publications and presentations, other support, contacts with other members of the network. Cooperation between NRI? For historical reasons or because of network?
8. Outside partners: frequency and type of contacts with Swedish researchers, value of these contacts compared to other international experts. With whom do you discuss new ideas, results, problems, changes in research plan, etc.
9. Budget: Is a fixed budget frame given (by whom), can it be changed, is it adequate. Procedure for application for funds. Delays in disbursement. Alternatives to funds from the network. Who handles the funds and who renders accounts?

The Project

1. Relation to own research agenda?
2. Additional financial support at hand? From where?
3. Use of results: publications, national and international meetings (who approves), balance between academic value and practical use.
4. Practical use, locally and globally. Interest from university/community. Relevance to society and local/regional situation. Harmonized with national policy.
5. Up-scaling of promising results: Links to decision makers, commercial sector. Financing of pilot plants. Sharing of costs and benefits. Ownership
6. Influence on society? (Debate, adoption of practices, economic effects)
7. Involvement of students, value of training. Student exchange?
8. How would you rate your group among other colleagues in the same field in your country
9. Provide list of publications emanating from your group, including contributions to conferences and workshops.

Ideas for Improvements

1. How can SAREC support be improved
2. How can networking be improved
3. How can usefulness of research be improved

C. Items covered in interiews with resource persons

Recruitment

1. When and why involved?
2. Previous experience of similar engagement

Activities

1. Tasks and responsibilities in ARRPET
2. Time spent, activities, inputs, level of detail in advice
3. Frequency of contacts with project leaders
4. Influence and role in acquiring additional funding
5. Views on scientific quality, relevance and practical potential
6. Views on the efficiency of use of resource persons
7. Views on importance of ARRPET to NRI
8. Has ARRPET contributed to increased awareness on environmental issues at government level? Policy impact? Practices? Views on sustainability
9. Views on commercialization of results

Ideas for Improvements

1. How can SAREC support be improved?
2. How can networking be improved?
3. How can usefulness of research be improved?
4. Would a similar approach be feasible in an African context?

Questionnaire to Principal Investigators

Questionnaire

The questions are all related to documents agreed on at the beginning of the projects. The questions may be too many to be all addressed in detail in writing, but I would deeply appreciate if you would kindly select at least those that you find most appropriate, and reply to them.

Thereafter we can deepen the discussions when we meet, addressing at that time also other issues if needed. Moreover, there may well be crucial questions that I have not included in the below questionnaire and I would very much appreciate if you ad such questions to the list.

Quality and relevance to the Asian region of research within the ARRPET frame, with focus on hard science and technology

1. Scientific methodology

Please comment on the scientific methodology used, addressing where appropriate

a. Literature review, knowledge of the status of science. Where initial literature reviews done? Covering which area? How were they used?
b. Formulation of objectives. Where objectives spelled out at the NRI level? Did the NRI contribute to theme objectives?
c. Formulation of hypothesis. Where research based on hypotheses?
d. Research plan
    1. Experimental design
    2. Field design of trials
    3. Relevance of location and methods for data collection
e. Evaluation of data
    1. Statistical data analysis when appropriate

2. Scientific results

a. Has high quality scientific results been generated? Please exemplify.
b. Has scientific results been generated which are relevant to the Asian region and which has focused on hard science and technology? Please exemplify.
c. Has the scientific results generated been relevant for, and have had an impact on, national and regional initiatives for policy plans controlling urban and environmental pollution?

3. Feasibility and relevance

Please comment on the below issues

a. Researchers' training and research experience related to the projects
b. Rationale for the research; analysis of problems; and identified beneficiaries
c. Feasibility of the project in relation to time and resources
d. Consideration of environmental and safety aspects
e. Likelihood of results to be applied
f. Relevance of results to scientific advancement
g. Relevance of results to national priorities
h. Relevance of results to socio-economic conditions

Mobilisation and strengthening of competence and capacity in the National Research Institutions (NRI) participating in the ARRPET Programme, in conducting research relevant for controlling urban and environmental pollution, and in relation to national and regional initiatives and policy plans

4. Gender and equity

a. Percentage of researchers of each sex, and total number of researchers participating at each NRI.
b. Did the scientific results take into consideration gender and equity, when appropriate?

5. Scientific capacity strengthening

a. At NRI: Composition of NRI research team, and changes over the years considered, with regard to academic degrees.
b. Has a critical mass of researchers been established at the Theme and NRI level. Are researchers outside ARRPET contributing to critical mass.
c. At regional level: To what degree have the NRI activities contributed to capacity strengthening? Has NRI team members left to be employed/take up studies elsewhere? Has this affected regional research capacity?

6. Networking

The four subject matter areas are organized as networks of participating researchers connecting national research institutes (NRI) to each others and to AIT. ARRPET can thus be described as a network of networks. Each subject matter area is led by a Principal Investigator. The PI are as a group responsible for execution, quality and administration of ARRPET. All participating researchers meet annually at a review meeting where progress for each project is presented and discussed. In addition there are one or several national meetings for each subject matter area. A Swedish resource person is attached to each subject matter area.

Please comment on the below issues:

a. Communication between researchers at each NRI
b. Communication between NRI
c. Continuous overview of the NRI activities by AIT (addressed to ARRPET Coordinator)
d. Overcoming varying scientific infrastructure and scientific tradition at NRI
e. Experts from Sweden; input, influence, impact
f. Researchers links with policy makers; contacts, influence, impact
g. Overcoming varying level of cooperation among governments in providing data to the researchers. To what extent has this been a problem?
h. Create links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas. Networking outside ARRPET to the benefit of ARRPET theme activities.

7. Support from AIT to research institutions

The program is coordinated by a Coordinator, Prof. Ajit P. Annachhatre, based at the AIT campus in Rangsit, Thailand, and each subject matter area is led by a Principal Investigator (PI), three of which are based at the same campus and one at Anna University in Chennai, India. The four PI and the Coordinator forms the unofficial Steering Group. Some projects have developed unofficial spin-off projects and the total number of researchers associated with the program may be in the order of 100.

a. Management: Has AIT supported in general management at Theme and NRI level?
b. Administration: Has AIT supported in administration at Theme and NRI level?
c. Coordination: Has AIT supported in coordination at Theme and NRI level?

d. Scientific supervision: Has AIT supported in scientific supervision at Theme and NRI level?
e. Running projects in actual practice: Has AIT supported in project management at Theme and NRI level?
f. Steering Group: Has AIT supported in the functioning of the Steering Group?
g. Annual Review Meetings. Importance to Themes and NRI?
h. Spin-off projects: the importance of these?

8. Achievement of goals

At the beginning of the project a Logical Framework Approach (LFA) matrix was made for each subject matter area as well as for the program as a whole. The LFA matrix lists objectives, expected results, activities, assumptions and indicators.

a. Where the objectives met?
b. Which outputs were generated? Output is defined as: "the products, capital goods and services which result from a development intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes"
c. Which outcomes were achieved? Outcome is defined as "the likely or achieved short-term and medium-term effects of an intervention's outputs"
d. Achievements in relation to the logical framework approaches developed July 2000 at AIT meeting
    1. Develop technical solutions adapted to local conditions
    2. Formulate policy recommendations for these solutions
    3. Strengthen existing research capacity in the region
    4. Disseminate the research results, academic as well as technical
e. How has the collaboration with EEPSEA which performs environment-financial analyses been?
f. What was achieved in relation to Environmental Impact Assessment (EIA) that was presented in AIT's project proposal?

Dissemination of results of the programme among policy makers and the possible impact on environmental policy (locally, regionally and nationally)

9. Dissemination of results

Please provide compilations of publications (journal impact factors considered) and other type of dissemination products:

a. Local peer reviewed journals
b. Global peer reviewed journals
c. Reports addressing technicians and end-users in actual practice
d. Reports addressing policy makers, easy-read synthesis report in order to influence policy making
e. Reports addressing product developers
f. Seminars

10. Implementation of results

a. Where technical solutions to environmental problems suitable for local conditions developed? Please exemplify
b. Where policy recommendations based on such technical solutions to environmental problems suitable for local conditions provided? Please exemplify.
c. Where science, technology, financial aspects and policy integrated? Please exemplify
d. Did the project contribute to strategically environmental friendly production

Finance

Asian regional research Programme on Environment and Technology (ARRPET) commenced in 2001 with a three years agreement period and a budget of 24 MSEK (approx 3.5 MUSD). The current phase amounts to 32 MSEK (approx 4.8 MUSD) and will complete its period of four years on December 31, 2007. Seventy per cent of the total is allocated to the NRI (equipment, data collection, travels, etc) and Swedish resource persons. Salaries are not paid to researchers at NRI. The remaining thirty per cent is allocated to AIT to cover costs for administration, publications, travels, project costs, salary compensation, etc

2001–2003 – 24 MSEK	
	70% to NRI – Research, Swedish experts, 70% Annual Review Meetings
	30% AIT – Project management, administration, 30% Annual Review Meetings
2004–2006 – 32 MSEK	
	70% to NRI – Research, Swedish experts, 70% Annual Review Meetings
	30% AIT – Project management, administration, 30% Annual Review Meetings

11. Finance

Please comment on the below issues:

a. How has funds been allocated between NRI?

1. Did NRI have an influence on fund allocation?
2. Has funds been distributed in a way that has not hindered the activities at NRI?

b. What is the proportion of ARRPET financing in relation to the overall financing of your research in the specific areas?

c. Would certain research project not have been realized without ARRPET financing?

d. What will happen to your research in certain areas if ARRPET financing will not be provided for the discussed Phase III?

e. Would you rather like to use potential funding for the discussed Phase III in some other way than just for a continued/enhanced research work in specific areas?

f. What are the co-funding options for the future?

Appendix 3: Names and Addresses of ARRPET Participants

(to the TL level)

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Appendix 4: Summary of Interviews from Fact Finding Mission

Network Structure

Role of the ARRPET Coordinator:

Coordination of the ARRPET program with 18 research institutions from 8 different countries is a complex task that requires necessary academic, administrative and financial skills. The responsibilities of the Coordinator involve administration, monitoring the research process and financial management.

Project Administration: Responsibilities involve negotiation, formulation and execution of contracts between AIT and Sida as well as between AIT and NRI, to organize Annual Review Workshops (in which all NRI, Sida officials as well as Swedish Resource Persons participate), and to prepare agreed minutes.

Monitoring of research progress: Research progress is monitored in cooperation with the PI of the respective Subject Matter Area. Responsibilities involve submission of progress reports as well as annual reports to Sida. This part also involves identification of non-performing NRI and to take necessary steps to improve their output in consultation with PI as well as Sida.

Financial Management: Responsibilities involve establishing an appropriate accounting system, receiving funds from Sida and disbursing funds to NRI, prepare the financial statements required by Sida, and to initiate yearly audits of the program, etc.

ARRPET III proposal preparation: ARRPET will be completing its Phase II in August 2008 and ARRPET Phase III is then being planned. Responsibilities involve overall coordination of the proposal preparation together with PI and NRI.

Website management: The coordinator has the responsibility to ensure that the website is updated with all reports that are published within ARRPET. The exception is reports accepted by international scientific journals that for copyright reasons only can be presented as summaries.

Multiple roles: The present Coordinator was from the start also Principal Investigator in the IHWTM SMA, but in 2004 the responsibility as PI of Waste Water was left. Still, the present coordinator is also PI of the IHWTM SMA and a TL in the WWTM SMA.

Role of Principal Investigators (PI)

The primary role of the ARRPET PI is to monitor the research progress by the NRI within each Subject Matter Area. While doing so, PI are also involved in their own research activities. Monitoring of NRI research leads to several activities such as report preparation, publication of successful research in international journals as well as planning future activities. PI also organize a regional workshop[6] once every year in which research progress as well as planning of research activities are discussed and agreed. It is the task of PI to search for synergies within the program and across the thematic programs. They also help to organize workshops, training programs, symposia and various project activities. Every PI is also a Team Leader

Role of Team Leaders (TL) and National Research Institutions (NRI):

The NRI are contract partners to AIT and researchers in NRI are expected to conduct the research along the lines agreed, led by the TL. The researchers are organized in networks that may include researchers from other universities that are not funded through ARRPET. Researchers organize national

[6] Sometimes referred to as "national workshop"

workshops where different stakeholders from academia, industry and governments meet and discuss implementation of research results.

Interviews with AIT President, and Principal Investigators

Professor Said Irandust, President of AIT

Professor Ajit P. Annachhatre, Coordinator of ARRPET and Principal Investigator IHWTM

Dr. Nguyen Thi Kim Oanh, Pricipal Investigator AIRPET

Professor C. Visvanathan, Principal Investigator SWLF

Professor Chongrak Polprasert, Co-Principal Investigator AIRPET

The general impression from these interviews is that the PI work well together as a team, are very active and have good control of the program. It was mentioned *en passant* that the scientific, administrative and financial reporting required by SAREC was a task that often had to be done outside normal working hours which were devoted to overseeing the projects, lecturing, managing their own research, and updating the website.

Training of network participants

Each project has its own training program and it is the responsibility of the NRI to arrange these activities, while AIT monitors them. Many training activities are advertised throughout the network and attract participants from several NRI both within and outside the country. At every scheduled regional meeting two days are set aside for training activities.

Transfer of knowledge within the network

Transfer of knowledge is directly between NRI. AIT does see itself as a hub in this activity, but sees the network as a fully disseminated network with a free flow of information between participants. To a degree, scientists from the different NRI exchange visits and share more expensive equipment that may not be available at every NRI.

Information dissemination

Being a research program the research is in the traditional way mainly disseminated though articles in peer reviewed publications and reports presented at scientific meetings. In this respect ARRPET has been very productive.

Among the objectives of the ARRPET were also to disseminate the results of the program among policy makers with a view to have an impact on policy plans. The program has not yet reached a stage where this has been addressed systematically. There are, however, a few examples where this has been accomplished to a degree.

Selection of projects

The NRI have been selected primarily by using the AIT network of research contacts and alumni.

New activities and research projects have required a research proposal that is made in the traditional SAREC format. It is submitted to the PI that makes the first comments back to the TL. The Swedish RP attached to ARRPET provide valuable input and communicate directly with the TL when the projects are formulated. The proposals are then discussed between all PI and approval and decision on funding is taken by consensus. There is no formal system for evaluating the proposals.

Monitoring, evaluation and auditing

There is no formal monitoring and evaluation system. The PI have good knowledge of each project within their respective Subject Matter Area through visits and the two scheduled regional meetings every year. At these meetings every theme is given one day for presentation and activities are reviewed by participants. At the end-of-year meeting about 80% of the time is spent on technical review and about 20% on administrative matters. In addition each NRI has to submit three reports every year (technical, administrative and financial). Auditing is done by the NRI themselves, according to the routines of their respective organization, and all reports are combined into a consolidated report by the PI and submitted to SAREC. All expenditures above 500 USD require a written justification and approval by the PI. Much time is devoted by the PI to follow what happens within the individual projects.

Contacts with network members

AIT is in close contact with many of the network participants, in particular the team leaders and meets them at the regional and selected national meetings. In some cases the PI also reviews manuscripts before publication and have thus good knowledge of research activities.

Application of results

AIT can not finance pilot scale projects from SAREC funds. This was not conceived as important during the ARRPET I phase as research had not arrived at the stage of being ready for implementation.

Among the objectives of ARRPET was to develop technical solutions to environmental problems and to adapt them to the local situation. The successful outcome with respect to this varies between the SMA, but there are examples of different degree of implementation from individual projects. Moreover, the network members have been consulted on technical matters that are outside the expertise of government officers. One example is the newly constructed waste water treatment system in the island of Phi Phi. The infrastructure of Phi Phi was destroyed by the tsunami. The disaster provided also an opportunity to create a completely new waste water system suited to the island. AIT mobilized its staff and students to assist the devastated areas immediately after the disaster. Implementation was financed by Denmark and the final result is remarkable (see Box 1).

Ideas for improvements/Discussion/Conclusions/Recommendations

The participants are in general quite satisfied with how the network has developed and the cooperation with SAREC. ARRPET can certainly use more funds to intensify activities among existing members and also include other, previously left-out countries in the region, such as Laos and Cambodia, as new members. Contacts with Cambodia are already there. However, an expansion of the network may mean a shift in the present workload away from technical matters to administrative tasks. According to the PI, there is already now too little time left for them to take active part in research activities. Should SAREC wish to expand the program this dilemma must be solved, either though tagging research students to the program, by providing MSc and PhD scholarships, or to finance the employment of administrative staff that could lessen the workload of the Coordinator and PI.

Interviews with Resource Persons

Professor Bo Mattiasson, Lund University, IHWTM

Professor Erik Särner, Lund University, WWTM

Professor Eva Selin, University College of Borås, AIRPET

Professor William Hogland, University of Kalmar, SWLF

Box 1. Sewage treatment in the island of Phi Phi.

Sewage treatment in the island of Phi Phi

AIT quickly mobilized its resources after the tsunami that struck the west coast of Thailand in December 2004. Volunteer students and staff traveled to the affected area both to participate in the rescue work and to plan for the reconstruction. The AIT management arranged several high-profile conferences to secure financial support from the international community for these efforts. AIT with its technical knowledge and history of community involvement had much to offer.

The island of Phi Phi was particularly hard hit with most of its infrastructure destroyed. Among other things the sewage treatment system had to be rebuilt. The previous system based on oxidation ponds was regarded as a smelly eyesore anyway. Phi Phi island receives about 1 million tourists per year. They come to experience the clear blue water and the clean environment. The first plan called for a conventional solution built around the activated sludge technology, which is the standard treatment method used in western countries. However, this expensive technology has never worked satisfactorily in Thailand, as evidenced by the about 80 plants around Thailand that are more or less useless. This is mainly because of the low BOD in incoming water, as households also are connected to their own septic tank. A centrally located municipal sewage treatment plant would in any case present an unsightly and odiferous dilemma in this serene island.

AIT has experience of another technology called Engineered Constructed Wetland. This technology is particularly suited to grey water, which is the type of waste water found in Thailand. AIT teamed up with environment planners, the local government and a donor (Denmark, as Sweden had decided not to give any support to Thailand) and managed to do the impossible – disguising the new waste water treatment plant as an attractive open space, with flower gardens, an open-air Thai-style public pavilion and a takraw court (a popular sport in Thailand). This "Constructed Wetland Water Remediation Plant" is innovative and has since its inauguration in December 2006 gained the attention of forward-thinking engineering firms seeking adaptable wastewater treatment solutions. The system consists of subsurface anthracite gravel filters, a surface flow constructed wetland and a polishing pond utilizing ultra-violet light for disinfection. A layer of bacteria on the filter aggregate breaks down pollutants. Grease is trapped in the septic tanks installed in homes and business and reduces impact on the wetland.

The new waste water treatment system works amazingly well. The system is simple with few pumps that can break down, no highly qualified technicians are needed, no chemicals are used and it is depending mainly on the sun as the power source. It is odor-free and visually appealing. The treated waste water is not released in the ocean as with the previous plant, but is all recycled for watering. The total cost, including the park, was about five million SEK, which is much less than for a conventional plant.

Table 1. Distribution of funds allocated for Resource Persons (as per 2001; SEK)

Specification	Amount
One week's salary including Swedish social costs	15,000
Travel (to Annual Review Workshop)	12,000
Accommodation and DSA for one week	10,000
Unforeseen	3,000
Total	**40,000**

In 1999 and 2000 the Swedish Ministry of Foreign Affairs published two important strategy documents that should guide the increased cooperation between Sweden and Asia ("Asiatiska Vägval" and "Framtid med Asien"). Increased support to AIT, support to regional cooperation on environment and closer cooperation between the Swedish resource base and Asian researchers were among the recommendations. SAREC echoed these recommendations in the project documentation submitted to the Board of SAREC and stressed the importance of attaching Swedish resource persons to ARRPET as a means to transfer know-how in environmental technology and create bilateral contacts.

The Swedish partners to ARRPET, assigned by SAREC as resource persons (RP), are not involved in the actual research projects. They act as peer reviewers with the task to review and comment. They also participate in the annual program meeting. Their limited involvement aims at avoiding conflicts of in-

terest in the contacts between AIT and SAREC. However, as one of the RP put it, independence is to a degree "compromised" because of gradually increased personal involvement.

In the Sida memorandum 2003 it is noted that in the proposal for ARRPET II it is suggested that four external expert advisers from Sweden are invited to participate in the Annual Review Meetings, to comment on the work that has been done and give their views on needs for modifications and improvements. The proposal from Sida is that such external advisors (one to each SMA) are engaged, and the program supports only their participation in the Annual Review meetings at AIT.

Of the four RP originally appointed two remain, while one left at the initial stage of the project (2001) and had to be replaced, and one recently (2006) has been replaced on his own demand.

The yearly amount set aside for each Swedish RP is 40 kSEK (Table 1)

One of the Swedish RP at an early stage pointed out to Sida/SAREC that the effect of the restricted budget may be that the possibility to devote the quality contribution expected might be compromised.

The Swedish RP were encouraged by Sida/SAREC to participate also in the regional meetings within their respective Subject Matter Area, but there were no funds allocated for that purpose.

In SAREC's presentation of the concept to its Board (Sida Research Council: 2000:2, item 4) ARRPET is presented as part of the objective to achieve a deeper partnership between Asia and Sweden in the field of environment and to raise awareness of Swedish environmental knowledge in Asia. A mechanism that could act as an intermediary between researchers in Asia and Sweden was foreseen. In some cases this vision of a close cooperation between the Swedish resource base and Asian academia was partially realized, but there have not been any attempts to systematically exploit this possibility. As the following interview material indicates, resources allocated did not allow for this.

When and why involved?

All RP were selected on individual basis by the ARRPET Steering Group, by using their research and Sida/SAREC contacts in Scandinavia. The RP have then been formally appointed by Sida/SAREC.

Previous experience of similar engagement

All RP have a solid experience of research in developing countries in their respective field of competence.

Tasks and responsibilities in ARRPET

There were no clear guidelines provided by Sida/SAREC to the tasks and responsibilities of the RP, but the budget constraints implied the limitations for the participation expected. As expressed in the interviews, the role of the RP was mainly as an external referee, by participating in the Annual Review Workshops and commenting on progress and work plans for new research activities. Perhaps the most important task has been to convince NRI researchers to abandon proposals for projects that will not end up in applicable results. That is, the role has primarily been as advisor, but in reality a controlling function has been equally important. (Later discussions with ARRPET participants on PI and TL levels revealed that they regarded the RP as being "their" resources, while the Sida/SAREC view is that the RP primarily is supposed to support Sida/SAREC personnel with scientific advise with regard to the program and its development).

Time spent, activities, inputs, level of detail in advice

This varies a lot between the RP depending on if time was spent also on reading and commenting manuscripts and having contacts with students. It seems that all RP spend considerable more time than provided for in the agreement with SAREC. The general view is that closer cooperation between the RP and ARRPET would be beneficial and would enable more integration between the different the-

matic areas. At least two of the RP have participated in at least one regional meeting on their own expense. This has been very useful, because input has been possible to give at an earlier stage than at Annual Review presentations.

Frequency of contacts with team leaders

Mainly during the Annual Review meetings, but when called for (reviewing manuscripts and project plans, etc.) by email in between those yearly occasions. In addition to that, some RP met TL at regional meetings.

Influence and role in acquiring additional funding

The RP feel that they have had considerable influence, in particular on the functional level, and in particular in the transition between ARRPET I and II. Their arguments for and against different elements have been taken seriously. However, they had little say on the general design of the project, including the choice of NRI and on which studies to focus on in ARRPET I, since this was already decided when the RP were engaged. The influence has been proportional to the time spent, and as all RP has spent more time than they were paid for, their influence has been higher than could be expected from their budget.

In some cases ARRPET PhD students have been involved in exchange with the university of the RP. That has required additional funding sought outside ARRPET. Otherwise, with one exception, the resource persons have not been involved in search for additional funds to ARRPET NRI, although, according to the interviews, some NRI managed to acquire complementary funding.

Views on scientific quality, relevance and practical potential

The scientific quality of the projects varies a lot, according to the RP, but the general opinion is that it is fairly high. The scientific publication rate appears satisfactory in general, but also here a substantial variation is apparent. One comment was that there are difficulties to get a scientific edge in studies in fields with multiple variables and restricted possibilities for replication. Such studies and results are easy to criticize, but may still be of a high practical and societal value. Another RP put the question what is the purpose of the network? Top-level research is not necessarily what is required when practical implementation of results is expected. Emphasis has been more on practical problem solving than on scientific excellence. A good balance is necessary to come up with results that are appropriate. A scientific strength has been that the cooperation has allowed for simultaneous studies replicated with parallels in several countries

The importance of practical implementation of the research projects were included from the very beginning as a filter when different ideas for research were discussed.There are some examples of research projects that have real potential of commercialization. On the other hand some projects have been abandoned and a few ongoing projects will never be applied in practice because they are not economically feasible.

The educational value is of high importance, there have been many students involved and their work, according to one RP, has been on the same level as that which can be expected from Swedish students. However, the research has not been demand driven, according to the RP, but has largely been depending of what competence and facilities were already in place.

Views on the efficiency of use of resource persons

The general view is that the RP have been used effectively, in particular in relation to their budget. If funds for travel between the annual meetings had been provided by SAREC they could have been even more useful in guiding research. However, the RP should have been involved already at the conception stage of ARRPET and not when the subject matter areas already had been decided by AIT and SAREC. The RP have greater experience of cooperation with industry and could have prevented some

"dead end" projects from being included from the beginning. There is now a tendency to put too much emphasis on very advanced technologies that is not appropriate for a developing country situation.

Views on importance of ARRPET to NRI

The main importance is the networking and the exposure to outside discussion partners. ARRPET has initiated systematic environmental research and thinking on a coherent level at the participating laboratories. However, the initial idea of a main project and a side-project at each laboratory has to a degree diverted the efforts, which has had negative influence on project development. Some NRI are quite well financed by their governments, while others have a need for additional funding for research and that now is provided by ARRPET. There is no doubt that ARRPET has raised the level of research at most NRI and much has been achieved through the ARRPET program.

Has ARRPET contributed to increased awareness on environmental issues at government level?

There was no such outcome after ARRPET I, according to the RP. ARRPET I, though, has been important in harmonization of methods and initial surveys and mapping of the state of environment that was needed to begin systematic research on the issues covered by ARRPET I and II. One PI has invited both journalists and policy makers to Regional Workshops, which may have influenced the awareness. In other Subject Matter Areas no such outreaching activities were carried out.

Policy impact? Practices? Views on sustainability

There has been some influence both on policy and certain practical applications. Effects can be seen in particular in countries like Indonesia, Sri Lanka, the Philippines and Malaysia, while countries like India and China are too big for much impact to be expected from a relatively small program like ARRPET. With regard to sustainability, the ARRPET network can not exist without the external funding.

Views on commercialization of results

That is a necessary aim in developing countries where the value of research has to be demonstrated to decision makers. RP and customers (industry or municipalities) must be involved from the very beginning if commercialization will happen. To the knowledge of the RP there are no commercial applications yet, but some research projects are being implemented on the pilot scale in cooperation with industry. Commercialization will not be possible in all cases.

How can SAREC support be improved?

The RP are willing to be more actively involved in the ARRPET projects, but SAREC would have to finance this. If the RP would have been allowed to participate at the department level, including undergraduate education, the research work would have been much more powerful and efficient, and progress faster – according to the RP.

How can networking be improved?

In general, networking has worked well. This is measurable, e.g. by the number of emails exchanged as statistics have been recorded and reported. Networking has been very beneficial, and has been improved considerably after initial remarks on shortcomings. In certain cases, though, language difficulties have limited the extent of networking.

How can usefulness of research be improved?

The present practice of each NRI to have a major research project and a minor project is not good. To achieve best impact research should be concentrated on one issue only. Economic evaluation of projects ideas should be mandatory before research is allowed to start, and the potential customer consulted from the start.

Most of the research is regarded as useful by the RP, but more efforts are needed to "sell" the ideas for implementation. Industry and consultants should be invited to seminars, where this is not already the case. Increased dissemination of popularized results is needed.

Not only technical solutions should be addressed to a larger extent, but also other means of control such as policy instruments and their implementation. Identification of possible obstacles should have been an important initial step.

Would a similar approach be feasible in an African context?

As Swedish universities aim for more international cooperation this would be welcome. Swedish universities could play an important role in upgrading environmental research in recipient countries.

One RP was very enthusiastic about this: *"Absolutely! The [ARRPET] working model is excellent!"* A starting point was suggested to be in a concrete example where existing solutions already have been implemented in a holistic framework, e.g. a "sustainable city section". Acceptance at higher political levels would be a necessary prerequisite. Such and approach must be interdisciplinary, not thematic, to avoid lack in communication between themes. But, an institution corresponding to AIT would be needed, with knowledgeable, resourceful and strong leadership. Needs strong leadership and a strong base! The process must result in documentation and learning adapted to African situation.

Interviews with Researchers

How and when did respondent get involved in project?

Many senior researchers involved in ARRPET have old contacts with AIT (alumni or former teachers) and some have come in contact with AIT staff through international conferences. In all cases the NRI has been invited by AIT to participate.

Selection of research subject: already ongoing or new, who took initiative, who formulated research plan, by whom was the plan vetted, who authorizes changes in plan, objective of project

At established NRI research was already ongoing in some form while others had little experience. The PI had the responsibility to lay a puzzle so that the NRI complemented each other and adjustments and changes in research plans happened frequently at the beginning. This was done in agreement between the team leaders and the PI.

NRI attitude to research and balance between academic and applied research

Research is high on the agenda, and in some cases more important than teaching. There is pressure that research results shall benefit society, which means industrial or societal application.

Relation to network: frequency and nature of contacts, reporting, feedback, meetings. Type of support (moral, financial, technical)

The natural venues for interaction are the two annual meetings – the Annual Review Workshop, where all NRI meet at AIT, and the Regional Workshop that takes place six months later. Besides this there are regional training workshops on e g analytical techniques ("peripheral skills"). The less experienced NRI value their direct contacts with other NRI in the same situation. There are many of these bilateral contacts within the network.

Complementarity or competition between NRI?

The research areas have been outlined with an intention of counteracting competition between the different NRI, but providing a complementarity in methodologies and techniques.

Nature of network: Disbursed or centralized, who decides, coordinating committee, how are activities decided, how are funds divided and disbursed

Project plans are submitted by the NRI and commented on by AIT as the Coordinator and the PI have the responsibility to streamline the program. Sharing of available funds does not usually generate controversy as it is clear what can be included in the budgets. There are sometimes, however, disagreements on technical issues and some NRI would prefer to discuss controversial issues directly with the RP rather than with the coordinating group. Sometimes it can be felt that the coordinating group has too much power as it both has authority over budgets and who can participate in the network. It seems that ARRPET was more centralistic during Phase I, while Phase II has developed into a more disbursed and democratic network.

Value of network: would the research project materialized without the network, value of moral and technical support, help with publications and presentations, other support, contacts with other members of the network. Cooperation between NRI? For historical reasons or because of network?

ARRPET network clearly means much more than access to funds for research. As one network participant said: "Regional research programs are very different from other programs. I have really learned a lot from my colleagues in this program. It is hard work, but I am very happy that I am involved in this". Another participant called it "a tremendous network and without it we could not have achieved what we have been doing". ARRPET has expanded the contact surface for many of the NRI and given access to training in several peripheral skills. Even if many projects would have materialized without ARRPET, research, especially at the less experienced NRI, would have been less successful or wouldn't have started at all. Researchers in developing countries are often intellectually isolated and lack colleagues with whom to discuss difficulties they face in their research. The ARRPET network in some cases provides the critical mass needed to successfully execute their research projects. Network contacts are mainly of two kinds: one with AIT and one to a sister NRI that work along the same lines. It seems that this NRI-to-NRI link is viewed as very beneficial. Concerning researchers, there is little of network-wide contact outside the mandatory meetings. One advantage of the network is the possibility of producing joint publications with two or more NRI as authors.

Outside partners: frequency and type of contacts with Swedish researchers, value of these contacts compared to other international experts. With whom do you discuss new ideas, results, problems, changes in research plan, etc.

Involvement of the Swedish RP is mainly limited to comments on research plans during Annual Meetings. Despite this, the input by resource persons is generally appreciated and the RP are viewed as helpful, devoted and professional. In some cases the RP is in close contacts with the research projects and provide technical know-how and accepts students for higher training. Participation in international research programs is not common and contacts are often limited to already established networks, such as ARRPET.

Budget: Is a fixed budget frame given (by whom), can it be changed, is it adequate. Procedure for application for funds. Delays in disbursement. Alternatives to funds from the network. Who handles the funds and who renders accounts?

Availability of research funds is good at NRI in countries such as India, China and Malaysia. The bulk of research expenditures come from government sources in these countries. ARRPET funds can in these countries be regarded as icing on the top enabling activities that otherwise would be difficult to finance. The situation in the Philippines and Indonesia is different. Thailand and Vietnam is somewhere in between. AIT has no access to funding that is open to Thai universities.

Funds are sent from SAREC to AIT and AIT distributes the agreed funds to the NRI. This distribution by AIT seems to be free of delays and red tape. Some NRI experience problems with their own administrations that can cause considerable delays. The NRI are responsible to render their own accounts that are sent to AIT for consolidation.

Relation to own research agenda?

In most cases there were at least some research activities along the same theme even before ARRPET. In those cases participation in the ARRPET program implied that research could proceed faster and more systematically than before.

Additional financial support at hand? From where?

Besides government funds and financial support from ARRPET no other sources are used or sought for the research carried out. In some cases, however, support was received from private investors for pilot-plant construction and running.

Use of results: publications, national and international meetings (who approves), balance between academic value and practical use.

Most researchers feel that practical use of results is the first priority of all projects. Academic outputs such as publications and presentations at conferences are a necessity, but not the highest priority.

Practical use, locally and globally. Interest from university/community. Relevance to society and local/regional situation. Harmonized with national policy.

In some cases the team leaders have discussed priority and value of their projects with national authorities to ensure that it is in line with national priorities.

Up-scaling of promising results: Links to decision makers, commercial sector. Financing of pilot plants. Sharing of costs and benefits. Ownership

Contact with end-users is a feature of most projects, but they usually have entered the scene at a rather late stage. The costs are shared by end-user admitting space for a pilot set-up while other costs are shouldered by the NRI. There are no negotiated agreements on ownership of intellectual property, yet, between an NRI and end-user.

Influence on society? (Debate, adoption of practices, economic effects)

Many team leaders are of the opinion that their research will have a major importance on society. In some cases the team leader foresees that their results may be of use internationally. None of the projects have aimed to start public debate about the particular environmental issue they are working on. Few journalists have been invited to ARRPET meetings.

Involvement of students, value of training. Student exchange?

There are quite a number of students that have benefited from ARRPET by receiving training within the ARRPET project by having been given a research task that could be used for thesis work. A few have been given the opportunity to do research at NRI outside the country. This has been greatly facilitated by contacts created through the network.

How would you rate your group among other colleagues in the same field in your country?

In most cases the NRI is the only place in their country that is doing research on the subject

How can SAREC support be improved?

Many NRI want to work with more advanced institutions of the kind that can be found in Sweden. There are now no funds available for this.

How can networking be improved?

The Annual Review Meetings are always located at AIT. It would be useful if these meetings could be rotated among the member countries and more of the research staff would be allowed to attend.

How can usefulness of research be improved?

Improved contact with end users already from the beginning. This has been achieved by a few NRI.

Appendix 5: Detailed Information of Subject Matter Areas and Compilation of Questionnaires

A. Waste Water Treatment and Management

Foreword

This compilation of the projects builds on a report written by Dr Guha in August 2007, [7], on a questionnaire replied to by all TL as well as the outcome from meetings with the team leaders, the teams and visits to pilot plants.

Purpose

The main goal of the Wastewater Treatment and Management (WWTM) Subject Matter Area (SMA) of ARRPET was to develop cost effective technologies for the region using local resources and expertise for the treatment of wastewater originating from cities, towns and villages of the region.

Organisational structure

NRI

Asian Institute of Technology (AIT), THAILAND

Indian Institute of Technology, Bombay (IITB), INDIA

Indian Institute of Technology, Kanpur (IITK), INDIA

King Mongkut University of Technology, Thonburi (KMUTT), THAILAND

Center for Environmental Technology and Management (CENTEMA), VIETNAM

Teams

Principal Investigator: Dr. Saumyen Guha, Indian Inst. of Technology, Kanpur, India

Team Leader: Dr. C.S. Harendranath, Indian Inst. of Technology, Mumbai, India

Team Leader: Dr. Nguyen Trung Viet, Vanlang University, Ho Chi Minh, Vietnam

Team Leader: Dr. Piyabutr Wanichpongpan, King Mongkut Univ., Bangkok, Thailand

Team Leader: Dr Ajit P. Annachhatre, AIT, Bangkok, Thailand

Swedish Resource Person:

2001–2006: Erik Särner, Lund University, Lund, Sweden

2006–2007: Jes la cour Jansen, Lund University, Lund,Sweden

Team members

AIT-Thailand

Prof. Ajit P. Annachhatre – ARRPET Coordinator

Ms. Raquel P. Pedrajas – Senior Research Associate

Ms Sawanya Laohaoprapanon – Research Associate

Mr. Apipong Lamsam – PhD Student (on-going)

Ms. Banashri Sinha – PhD (completed)

[7] Guha, S. (2007) A Brief Report on Wastewater Treatment and Management Project in Asian Regional Research Project in Environmental Technology (ARRPET) Phase II, with inputs from the NRI of WWTM. Indian Institute of Technology, Kanpur, UP 208016, INDIA

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Mr. Songkeart Phattarapattamawong

Mr. Nguyen Phuc Thanh

Ms. Mayuree Tonkham

Mr. Bhaskar Ray

Mr. Tharmalingam Suthakar

Mr. Jenyuk Lohwacharin

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Dr. Somkiet Techkarnjanaruk (Ph.D. Molecular Microbiology)

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Subprojects

In terms of pollutants, the project in Phase II targets carbon and nitrogen removal. The distribution of NRI according to the pollutants is:

- Carbon Removal: IITK, IITB and CENTEMA
- Nitrogen Removal: AIT and KMUTT

Based on the local economy, the wastewater may consist of pure domestic sewage, domestic sewage mixed with small-scale industry wastewater and agro-industry wastewater. The distribution of NRI according to the wastewater is:

- Domestic Wastewater: IITK and IITB
- Agro Industry Wastewater: CENTEMA
- Shrimp and Seafood Industry wastewater: AIT and KMUTT

NRI are working on a diverse range of unit processes such Upflow Anaerobic Sludge Blanket Reactor system: IITK, IITB and CENTEMA
Photo-bio reactor system for shrimp pond wastewater: KMUTT
Nitrogen removal by anaerobic process: AIT

In Phase II, all the NRI were conducting laboratory experiments with real wastewater and successfully demonstrated the applications in Pilot Scale treatment plants.

According to the PI Dr. Guha all the projects were proved superior compared to the benchmark technologies[8].

Two core concepts were applied for the projects.

- The research consisted of a combination of development of novel technology and adaptation of the existing unit processes to local environmental problems.
- While developing the technologies, special attention was given to utilization of low cost and locally available materials and expertise.

Research at the Asian Institute of Technology

Title: Efficient Process for Wastewater nitrogen removal

- To evaluate feasibility of variety reactor types such as fluidized bed reactor, fixed bed reactor, granular sludge reactor, etc. for removal of nitrogen from domestic wastewater with methane as electron donor.

[8] Guha, S. (2007) A Brief Report on Wastewater Treatment and Management Project in Asian Regional Research Project in Environmental Technology (ARRPET) Phase II, Indian Institute of Technology, INDIA.

- To investigate the start up and operation of most appropriate nitrogen removal process from domestic wastewater with methane as electron donor.
- To investigate the effect of dissolved oxygen on removal of nitrogen using methane as electron donor
- To develop operational and disposal guidelines for disposal of treated wastewater

Results

A novel process called combined Activated Sludge with Partial Nitrification (AS/PN) was coupled with Anaerobic Ammonium Oxidation (ANAMMOX) process to remove nitrogen from the wastewater. Target wastewater in this case was effluent after the secondary treatment of sewage and from seafood industry. Several experiments, both in laboratory and pilot plant scale, were conducted to develop the novel process, which can simultaneously and efficiently remove both organic carbon and nitrogen pollution. In the laboratory experiments, maximum nitrogen removal rate was 1.4 kg N m-3 d-1 at ammonium and nitrite concentrations of around 375 and 350 mg N l-1, respectively. The experiments demonstrated that combined AS/PN – ANAMMOX process is stable for wastewater containing high ammonium up to 700 mg N/l. Pilot scale experiments with real wastewater from seafood industry also showed satisfactory results.

Research at the Indian Institute of Technology, Bombay (IITB), INDIA

Title: Characterization of bio-solids from UASB/Activated Sludge process/Fluidize bed process

- Monitoring granule size distribution in UASB through Image analysis throughout UASB operation/performance. Correlating granule size distribution with UASB reactor performance.
- Studying morphology/structure of granules through ESEM/SEM at various stages of UASB operation
- Examinations of ecological association within a granule through TEM.
- Characterization of Bio-solids from UASB/Activated sludge process and Fluidized bed from other NRI.
- Networking with other NRI.

Results

Enhanced granulation in UASB reactor with low strength wastewater, as described in IITK above was conducted as a collaborative project between IITK and IITB. While the reactor operation and monitoring of chemical and biochemical parameters were conducted at IITK, the granule examination and characterization using Image Analysis (IAS), Environmental Scanning Electron Microscope (ESEM), Electron Probe Micro Analysis (EPMA) and Transmission Electron Microscope (TEM) were conducted at IITB. Close collaboration between the two institutes enabled development of an applicable technology. The pilot plant for the enhanced granulation is also being operated jointly between IITK, IITB and VWEMCL. In addition, IITB acted as a hub for bio-solids characterization for all the NRI in WWTM project and IHWTM project in ARRPET.

Research at the Indian Institute of Technology, Kanpur (IITK)

Title: Treatment of Domestic Wastewater in India: UASB Optimization

- Enhanced granulation with real wastewater, linked to IIT-B
- Reduce start-up time with real wastewater
- Understanding of effect of nutrients, key metal concentrations and microbial ecology on granulation and performance, linked to IIT-B
- Analyzing ecology and stability of the granules and resulting UASB reactor performance with real wastewater, linked to IIT-B

- Networking with other NRI, especially on microbial ecology and phytoremediation

Results

A field and literature survey during Phase I of ARRPET indicated that the UASB process for treatment of low strength wastewater suffers from i) longer start-up times, ii) inability to form self-immobilized iii) bacterial granules and very low bio-gas recovery.

Thus the primary objective of the project was to achieve better granulation in UASB reactors treating low-strength wastewater. This was achieved using locally available and low cost natural polymer additives such as Reetha seed *(Sapindus trifoliata)* extract and Chitosan. It was also shown that the enhanced granules were stable for long period under various shock loading without requiring further doses of the additives. Large granules were generated in the reactor using real sewage with COD concentration varying randomly between 100–200 mg/L. More than 80% COD removal could be achieved with an HRT of only 2.5 hours in the sludge bed and 4.5 hours overall including the settling zone.

The 100 m3/day pilot plant has been funded by Vapi Waste and Effluent Management Co. Ltd. (VWEMCL) and is operated jointly by IITK, IITB and VWEMCL.

Research at the King Mongkut University of Technology, Thonburi (KMUTT), Thailand

Title: Bioremediation and reuse of marine shrimp Farm Effluent

- Determination of light/dark period for optimum nutrient removal of Chlorella sp.
- Find optimum operating conditions of photobioreactor for treatment of effluent in shrimp farm.
- Performance of Bioremediation and reuse of shrimp-farming effluents.

Results

This project attempted to develop cost-effective methods for removing ammonia nitrogen from shrimp pond water prior to discharge to the environment by utilizing photosynthesis activity of micro-algae developed in shrimp-pond. The key was to determine the light/dark period and mixing condition for optimum nutrient removal by green algae (Chlorella sp.). It was observed that the light/dark ratio and mixing are closely related parameters. In a shallow well-mixed tank, the light requirement is less compared to a deep tank with less mixing. In the laboratory scale experiments, maximum ammonia nitrogen removal rate observed was 0.71–0.98 mg-N/mg-Chl-a/h. At the pilot scale the nominal ammonia nitrogen removal rate was 0.06 to 0.15 mg-N/mg-Chl-a/h which increased substantially to 0.50 mg-N/mg-Chla/ h with mixing, bringing it close to the laboratory reactor observation. Treatment of the sediment from the shrimp pond was considered as the minor issue and preliminary investigations were conducted for biogas production, nutrient leaching and fate of microbial population during the drying process.

Research at the Center for Environmental Technology and Management (CENTEMA)

Title: Sustainable Development of Tapioca Processing Industry in Vietnam

- To develop a methodology for analyzing and designing pollution prevention models for industries;
- To develop a zero waste industrial ecosystem for tapioca processing industry at village level;
- To develop a zero waste industrial ecosystem for tapioca processing industry at company level;
- To develop a general zero waste industrial ecosystem model for tapioca processing industry in Vietnam;
- Improvement of environmental management system and policy to put the developed model to work.

Results

The goal of this project was to develop a model for the sustainable development of tapioca industry at the village level through waste minimization, reprocessing and recycling. Proposed wastewater treat-

ment system consisted of the UASB reactor system combined with an aerobic activated sludge process and stabilization ponds. The treated wastewater was reused for irrigation in the area for cassava cultivation and on the surrounding agricultural land. The wasted sludge from wastewater treatment plant and cassava root peel was used for composting. The compost produced was applied for the cassava and corn cultivations. The fish produced in the stabilization ponds were edible and was a source of revenue. In this way, the target was to create a zero waste industrial ecosystem for the tapioca processing villages, where solid waste and wastewater can be gathered and treated at the central treatment units in the area.

Networking

Networking was achieved at three different levels as below:

1) Research networking through collaboration between two or more NRI
2) Transfer of technology and development of expertise through specialized workshops
3) Research collaboration between NRI and industry partners through pilot scale experiments

For example, IITK and IITB are collaborating closely. IITB is contributing with reactor experiments and IITB is contributing with analyses of the water. Also, NRI from the WWTM SMA has been collaborating with the IHWTM SMA, which lead to interaction and synergy between two projects in ARRPET. By close interaction between the NRI, many research problems were resolved such as

- characterization of biosolids, analytical methods for target compounds and metabolites
- analysis of microbial ecology
- identification and characterization of phytochelatins in phytoremediation

The NRI from the WWTM and IHWTM SMA meet every year in a combined regional workshop to foster networking. Eight specialized training workshops have been organized so far for the NRI in WWTM. Besides, there were six more training workshops for the industry partners. Collaboration with industry partners through pilot plant opened up the possibility for future transfer of technology developed in ARRPET.

Dissemination

Knowledge dissemination from ARRPET project was conducted at multiple levels.

- The technologies developed were published in peer-reviewed journals and were presented at national and international conferences.
  - Twelve articles in peer-reviewed journals have already been published and 8–10 more are in the process of preparation or review
  - A total of 14 papers have been presented and published so far at National and International conferences.
- Four national workshops were held by the NRI in order to keep the stake holders and policy makers informed about the technologies developed within ARRPET.
- The NRI from WWTM and IHWTM SMA published two newsletters every year. The newsletters were circulated widely through internet and were targeting the non-technical community.

Capacity Strengthening

- Capacity strengthening activity was mainly targeted towards strengthening technical manpower. To this end, most of the NRI had large success by guiding Masters and Ph.D. students as part of the project activity.
- Some laboratory infrastructure was built from the funding of minor equipment in the project.

Administration

Administrative structure of WWTM project consist of a Principal Investigator (PI) designate from amongst the NRI whose duty is to

- monitor the NRI projects on a regular basis in consultation with a Swedish expert,
- give timely feedback to the NRI,
- enforce the project requirements and
- prepare the project reports.

The financial matter is handled by AIT. There was a change of PI in the WWTM project in the year 2004 and a change of Swedish expert in the year 2006.

Compilation of Questionnaire

Method of interpretation

The replies by each NRI have been compiled below in the form of a scoring system; 1–5 representing as below:

1) not achieved
2) almost achieved
3) achieved
4) excellent
5) very excellent

The scoring builds on compilation of the results from each NRI, meetings with the team leaders and many of the students. Such a scoring method is used to try to facilitate the understanding for the reader but will be subjected to the evaluator ability to interpret correctly the replies. The evaluator urges that she made her best in being objective and open-minded, but obviously the scoring is subjective. The reviewer claims that the method still gives a good rough view of the actual situation.

The scoring represents and average of all NRI. If the variation is large among the NRI a range of scores has been presented. In the section about finance where the scoring numbers cannot be used to express the situation, they have been replaced by words.

Questions	Score	Comment
Quality and relevance to the Asian region of research within the ARRPET frame, with focus on hard science and technology		
Scientific methodology		
Literature review, knowledge of the status of science. Where initial literature reviews done and the knowledge implemented into the project?	2–4	
Formulation of objectives. Where objectives spelled out at the NRI level? Did the NRI contribute to theme objectives?	4	Through LFA
Formulation of hypothesis. Where research based on hypotheses?	3	They were there but not stated
Research plan – Experimental design, field design of trials relevance of location and methods for data collection	4	
Evaluation of data, statistical data analysis when appropriate	2–4	
Scientific results		
Has high quality scientific results been generated?	2–5	
Has scientific results been generated which are relevant to the Asian region and which has focused on hard science and technology?	5	

Questions	Score	Comment
Has the scientific results generated been relevant for, and have had an impact on, national and regional initiatives for policy plans controlling urban and environmental pollution?	3–4	Relevant but little impact
Feasibility and relevance		
Researchers' training and research experience related to the projects	5	
Rationale for the research; analysis of problems; and identified beneficiaries	5	
Feasibility of the project in relation to time and resources	3	Research are still needed until the goals of phase II is achieved
Consideration of environmental and safety aspects	4	
Likelihood of results to be applied	2–3	It is not obvious that the addressed end-users will be convinced
Relevance of results to scientific advancement	4	
Relevance of results to national priorities	4–5	
Relevance of results to socio-economic conditions	4–5	
Mobilisation and strengthening of competence and capacity in the National Research Institutions (NRI) participating in the ARRPET Programme, in conducting research relevant for controlling urban and environmental pollution, and in relation to national and regional initiatives and policy plans		
Gender balance and equity		
Percentage of researchers of each sex, and total number of researchers participating at each NRI	1–3	Gender balance among students but not among leaders
Did the scientific results take into consideration gender and equity, when appropriate?	NA	
Scientific capacity strengthening		
Composition of NRI research team, and changes over the years considered, with regard to academic degrees	4	Not so many PhDs
Has a critical mass of researchers been established at NRI	2	The researchers leaves when they have received their exam
Are researchers outside ARRPET contributing to critical mass at NRI	4	
To what degree have the NRI activities contributed to capacity strengthening at regional level?	4–5	
Has NRI team members left to be employed/take up studies elsewhere	5	
Has the leaving of researchers affected regional research capacity	3	As much as can be expected
Networking		
Communication between researchers at each NRI	4	
Communication between NRI	2–4	
Continuous overview of the NRI activities by AIT (addressed to ARRPET Coordinator)	3	
Overcoming varying scientific infrastructure and scientific tradition at NRI	2	Little understanding about each others situation
Experts from Sweden; input, influence, impact	2	Has been changed and is not around a lot

Questions	Score	Comment
Researchers links with policy makers; contacts, influence, impact	1–2	Not always aware this was an objective
Overcoming varying level of cooperation among governments in providing data to the researchers. To what extent has this been a problem?	NA	
Create links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas	1	No activities in urban areas
Networking outside ARRPET to the benefit of ARRPET theme activities	3	
Support from ARRPET coordinator at AIT to research institutions		
Has AIT supported in general management at Theme and NRI level?	4	
Has AIT supported in administration at Theme and NRI level?	4	
Has AIT supported in coordination at Theme and NRI level?	3	
Has AIT supported in scientific supervision at Theme and NRI level?	1	Not perceived as part of mandate
Has AIT supported in project management at Theme and NRI level for the Running projects in actual practice?	1	Not perceived as part of mandate
Has AIT supported in the functioning of the Steering Group?	1	Steering group never met
Importance of Annual Review Meetings to Themes and NRI?	5	Everybody agrees it is of major importance
Spin-off projects: the importance of these?	4	
Achievement of goals		
Where the objectives met as defined in the ARRPET program Logical Framework Approach (LFA) matrix?	4	The results have been continuously compared with LFA by PI
Where expected outputs generated? Output is defined as: "the products, capital goods and services which result from a development intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes [9]	1–3	Too early, maybe later in the project
Where expected outcomes achieved? Outcome is defined as "the likely or achieved short-term and medium-term effects of an intervention's outputs"	3–4	
Formulated policy recommendations for these solutions	1–4	Not all NRI aware that part of objectives
How has the collaboration with EEPSEA which performs environment-financial analyses been?	1	No-one is aware of EEPSEA
What was achieved in relation to Environmental Impact Assessment (EIA) that was presented in AIT's project proposal?	4	
Dissemination of results of the programme among policy makers and the possible impact on environmental policy (locally, regionally and nationally)		
Dissemination of results		
Local peer reviewed journals	2	
Global peer reviewed journals	1–5	
Reports addressing technicians and end-users in actual practice	2–4	
Reports addressing policy makers, easy-read synthesis report in order to influence policy making	1	Not aware it was an objective
Reports addressing product developers	NA	
Seminars	3	

Questions	Score	Comment
Implementation of results		
Where technical solutions to environmental problems suitable for local conditions developed?	3	This was always addressed but final results not yet delivered
Where policy recommendations based on such technical solutions to environmental problems suitable for local conditions provided?	1	Not aware it was an objective
Where science, technology, financial aspects and policy integrated?	2	
Did the project contribute to strategically environmental friendly production	NA	
Finance		
Did NRI have an influence on fund allocation between NRI?	1	Team-leaders were content with this
Has funds been distributed in a way that has not hindered the activities at NRI?	3	Possibility for reallocation between budget items was needed
What is the proportion of ARRPET financing in relation to the overall financing of your research in the specific areas?		In the order of half
Would certain research project not have been realized without ARRPET financing?		Yes
What will happen to your research in certain areas if ARRPET financing will not be provided for the discussed Phase III?		Most likely interrupted
Would you rather like to use potential funding for the discussed Phase III in some other way than just for a continued/enhanced research work in specific areas?		Only minor changes
What are the co-funding options for the future?		Was not addressed

B. Sustainable Solid Waste Landfill Management (SWLF)

Foreword

This compilation of the projects builds on:

- a questionnaire to PI and all team leaders
- visits to NRI and AIT. Team leaders/PI was the main respondent during these visits but opportunity was also provided for interaction with the research team and stake holders that had worked together with, or benefited from the ARRPET project.
- information provided during the visits and on the Solid Waste Landfill Management SMA home page www.swlf.ait.ac.th/index2.htm

Purpose

Development mission of the Sustainable Solid Waste Landfill Management **in Asia project:**

Enhancing solid waste disposal practices and landfill technology for efficient and effective solid waste management in the region.

Project objectives (technical):

Identify the existing solid waste management practices and characteristics Development of technically feasible solutions related to various components of landfill design and operation. Identify the policy and institutional limitations and flows in Sustainable Solid Waste Landfill Management in Asia.

[9] Molund, S and Schill, G (2007). Looking Back, Moving Forward. Sida Evaluation Manual, 2nd revised edition, Sida, Department for Evaluation and Internal Audit, Stockholm, Sweden.

Landfill is the treatment option available for the absolute major part of waste in the region. A very large part is actually put on open dump sites. The initial field of research, given by Sida, was Solid Waste (in general). Given the existing waste management practices in the region, researchers field of expertise/ experiences, and a request from Sida to narrow the focus of the theme, it finally became "Sustainable Solid Waste Landfill Management in Asia" (SWLF).

This theme is probably the one that is most relevant to the Sida overarching objective as inadequate waste management affects the poor more than others.

The group decided on three objectives in a LFA workshop preceding Phase II: one for technological aspects (se above), one for networking among NRI and one for policy and institutional aspects.

The group also set up objectives for networking and policy & institutional aspects.

A description of the objectives, along with indicators, sources of verification and assumptions can be found in the LFA-matrix www.swlf.ait.ac.th/Proposal/lfamatrix.htm.

The core concepts of the research were

- to identify the existing solid waste management practices and characteristics and
- develop technically feasible solutions (that are better than todays practice) under the given constraints in the region
- to identify the policy and institutional limitations and flows in Sustainable Solid Waste Landfill Management in Asia.

Organisational structure

The PI of the SLWF SMA is Prof. C. Visvanathan (who is also team leader for the NRI at AIT). Swedish Resource Person is William Hogland, Department of Technology, University of Kalmar. For all NRI, in the SLWF SMA, contracts with AIT are signed by university (Dean, Vice Chancellor etc) i.e. would still be valid if team leader left the project.

The NRI are:

Country		Team leader
AIT	Environmental Engineering and Management (EEM), Urban Environmental Engineering and Management, AIT,Bangkok.	Prof. C. Visvanathan
China	National Engineering Research Center for Urban Pollution Control (NERCUPC), Tongji University, Shanghai.	Dr. Zhou Gongming
India	**Center for Environmental Studies** (CES), **Anna University,** Chennai.	Dr. Kurian Joseph
Sri Lanka	Solid Waste Research Unit (SWRU), Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya	Dr. B F A Basnayake
Thailand	Department of Environmental Engineering, Faculty of Engineering, **Kasetsart University,** Bangkok	Dr. Chart Chiemchaisri

Team members

AIT – Thailand

Prof. C. Visvanathan (PI)

Ms Radha Adhikari (Research Associate)

Mr Thar Thar Zan (Research Assistant)

NERCUPC – China

Dr Zhou Gongming (team leader) Associate Professor of Environmental Engineering, Deputy Director

Dr Chen Dezhen, (co-team leader), Professor of Thermal Engineering.

Prof. Gao Tingyao Professor of Environmental Engineering, Director

Dr Zhu Xiaojun, Environmental Engineer (technician).

CES– India

Dr. K.Thanasekaran, Director and Professor of Environmental Engineering

Dr. Kurian Joseph (team leader) Assistant Professor in Environmental Engineering and Principal Investigator

Dr. R.Nagendran, Professor of Environmental Sciences and Co-Investigator

SWMU – Sri Lanka

Dr. B F A Basnayake (team leader), Senior Lecturer Natural Resource Engineering

Dr. D.N Jayatissa, Senior lecturer Agricultural Engineering

Mr. Nalin Mannapperuma, Research Associate, Solid Waste Landfill Management in Asia-AIT-Sida Project

Mr.A.S.H Chandrasena, Technical Officer, Solid Waste Management Research Project

Ms. F Farouk, Project Secretary, Solid Waste Management Research Project

Kasetsart University –Thailand

Dr. Chart Chiemchaisri (team leader) Assistant Professor

Ms. Wilai Chiemchaisri Lecturer

Ms. Cheema Chomsurin Lecturer

Ms. Thipsuree Kornboonraksa, Research Associate

Ms. Siraprapa Threedeach, Research Associate

If no other information is given team members belong to the same department as the NRI.

All NRI involve students in their research work for longer or shorter term. Only the parts of the students work/studies that are directly connected to ARRPET are financed by the project.

Subprojects

At the initial LFA-workshop the SWLF-groups identified five technologies related to landfill practice that should be covered in the project:

- anaerobic digestion – AIT
- pre-treatment/composting – Sri Lanka
- landfill mining – India
- Refuse Derived Fuel[10] (RDF) – China
- Methane oxidation (top cover) and bioreactors – Thailand

These are now found under four subprojects ("research themes" in the LFA matrix):

1) Issues related to sustainable landfill operation
2) Pre-treatment of various wastes

[10] Leachates was changed to RDF to not overlap with the Waste Water-NRI in China.

3) Landfill emissions treatment and
4) Dumpsite upgrading.

To be able to produce the expected technological outcomes, it was also decided that each NRI should carry out research on two major and one minor topic. At least two NRI should be involved in each topic (see description of NRI below or project home page www.swlf.ait.ac.th/nris%20details/nrimain-page.htm)

Each NRI and AIT is also responsible for generation the expected outcomes concerning networking and policy, legislation and institutional factors.

The networking has been developed during the whole project (but was more focus of attention during Phase I). The activities under this objective are for example: formulation of common work methodology for networking, country specific case studies on landfill management, development of common teaching material, collection of references (on "Roadmap" and home page), and disseminations of results (www.swlf.ait.ac.th/Proposal/lfamatrix.htm).

Each NRI is to carry out two major and one minor research topic (Table 1). The topics are chosen to cover all the five technologies identified in the beginning of the project (Phase I). At least two NRI should be involved in each topic. The rational/need for the given topics is basically the growing amounts of waste and the fact that the major part of the waste is put not adequately managed today, i.e. put on landfill or open dump sites. The objectives for each NRI (according to the SWLF homepage) are given below.

Environmental Engineering and Management (EEM), Urban Environmental Engineering and Management, AIT

This research will focus mainly on the specific consideration of the regional features and peculiarities; the main objectives of the research activities, are:

Leachate quantity and quality determination using laboratory scale, pilot scale and actual landfill.

- Development of leachate pre-treatment and final treatment module to cope up with variation of leachate characteristics and quantities with time.
- Laboratory scale and pilot scale experiments on methane oxidation using compost materials as cover soil.
- Construction of pilot scale landfill to compare the results from lab scale experiments carried out by NRI and AIT team with respect to degradation, gas generation, leachate quantity and quality parameters and methane oxidation in cover soil.
- Electronic Networking

The minor objectives of the study are;

- Study of pretreatment of solid waste using passive aeration for emission reduction.
- Study of factors influencing the water management of landfills under local conditions.

Table 1. Subprojects and major/minor research topics (according to LFA matrix)

Subprojects	NRI working on subproject	
Issues related to sustainable landfill operation	**Major**	**Minor**
1. Continuation of lysimeter studies MSW/pre-treated waste/open dump Simulation and incorporating monsooning effect on leachate management	AIT/ Sri Lanka	
2. Lysimeter studies to simulate aerobic/ anaerobic landfill bioreactor, and incorporating the biological top cover to enhance methane oxidation	AIT/ Thailand	
3 Lysimeter studies to simulate controlled dump conditions	India/AIT	
Pretreatment of various wastes		
4. Optimization of the developed composting[11] system and improvements with odour and fly controls	Sri Lanka	
5. Anaerobic digestion of the MSW as pre-treatment prior to land filling	AIT/ Sri Lanka	
6. Anaerobic leaching/flushing of MSW combined with aerobic/ anaerobic bioreactor		AIT
7. Anaerobic "dry" fermentation		
8. Microbiological characteristics of enriched consortium for methane oxidation[12]		China/Thailand
Landfill emissions treatment		
9. Provide upgraded and cost effective alternative processes for leachate treatment of both young and old leachate		China/AIT
10. Development of low cost natural leachate treatment system using wetland		Thailand/China/ Sri Lanka
11. Development of sustainable and enhanced methane oxidation layer for tropical landfill	Thailand	AIT/India
12. Methane and VOC emissions at Landfill sites and open dump in Thailand: Field monitoring, Inventory, incorporating GIS, source identification and other lab scale experiments.		Thailand/AIT/India
13. Evaluation of geotechnical and methane oxidation characteristics of soil fraction from dumpsites		India
Research Theme: Dumpsite upgrading		
14. Focus on how to reuse and rehabilitate the landfill site and reduce nuisance, pollution and achieve working safety		India/Sri Lanka
15. Leachability studies on wastes from the lysimeters/dumpsites at different state of degradation		India/Sri Lanka

National Engineering Research Center for Urban Pollution Control (NERCUPC), Shanghai, CHINA

The general objective of the study is to develop a practical technology for the treatment of various concentrations of leachates from different kinds and age of landfills in china, which could be applied in other developing countries. The main objectives of the study are as follows:

- Develop a new technology for leachate pre-treatment to improve its biodegradability. It could be used especially for old landfills.
- Investigate the stabilized landfill chambers or composted solid waste landfill chamber as post treatment units for further removal of residual organic and NH4+ N of biologically treated effluents to meet more stringent discharge regulations instead of expensive pre-treatment methods such as RO, activated carbon, or chemical oxidation.
- Provide optimized treatment processes for various characteristic of leachates from different kinds and age of landfills so that cost in capital investment and operation could be saved obviously.

[11] Composting as a pre-treatment method before landfilling (volume minimisation).
[12] The success of this project is doubtful. The team did not have enough microbiological competences/experience.

Center for Environmental Studies (CES), Anna University, Chennai, India

The proposed research will include investigations focusing on the upgrading of the two dumping sites at Kodungaiyur and Perungudi, in Chennai. The objectives are:

- To assess the physico-chemical characteristics of the waste samples from different locations of the dumps.
- To conduct leachability studies on municipal solid wastes at different degradation states.
- To monitor the ground and surface water quality around the existing dumpsite to assess the current status.
- To predict the impacts on groundwater quality due to leachate contamination.
- To assess the feasibility of stabilizing the partly degraded organic solid wastes by vermicomposting in the land dumps.
- To assess the feasibility of using the stabilized wastes from the dumps as compost as well as daily cover material
- To investigate the potential of using locally available clay liners or bentonite clay liners
- To investigate the kind of vegetation that can be developed over the dump sites

Solid Waste Reserch Unit (SWRU), Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya

Objectives of the Study

- To undertake laboratory, lysimeter studies and field investigation of landfill dynamics and compilation of data for publications.
- To minimise production of leachate by reducing the organic matter content by aerobically treating the waste prior to landfill.
- To confine the leachate formed under anaerobic conditions within the landfill by considering it as an anaerobic bioreactor.
- To increase the compaction in aerobic treatment prior to landfill and to combine sludge formed by anaerobic digestion with compost for final closure of cell or cells (Sub Layers).
- Undertake studies for eventual reclamation or closure of existing landfill sites.
- To assist in formulating new legislature and policies for municipal solid waste management with particular reference to landfill management.
- To disseminate the findings by conducting seminars, workshops and short courses. And improvement of curricular in the Universities.

Department of Environmental Engineering, Faculty of Engineering, Kasetsart University, Bangkok, Thailand

The experiments on bioreactors were mostly performed under semi-arid climate condition using wastes with relatively low moisture content. MSW from developing countries are mainly composed of easily biodegradable organic compounds with high moisture content (Luis et al., 1997) especially in tropical countries therefore providing different environmental conditions for the waste degradation process. Therefore, this research proposal aims to investigate the feasibility of applying landfill bioreactor concept to tropical landfill in developing countries. The scope of research covers the aspect of landfill gas management including enhancement of landfill gas production and reduction of methane gas emission from landfill through final cover design.

The experiment will be conducted both in laboratory scale and actual landfill site. This is to ensure that the results obtained from the laboratory are applicable in actual practice. In order to avoid excessive cost of site modification, pilot landfill site at Nakhonprathom municipality in Thailand with approximate area of 8,000 m2 is selected as the experimental site.

Results

In Phase I, capacity mobilization at NRI, and assessments of existing solid waste management practices and characteristics were carried out. All the NRI were conducting laboratory experiments.

In Phase II, the laboratory experiments were continued and all the NRI successfully demonstrated the applications in Pilot Scale treatment plants.

According to the project leaders all the projects were proved superior compared to the methods practiced today.

All updates on results (publications, workshops, interaction with stakeholders/policy makers etc) are sent to AIT and by them presented on the projects home page.

Phase III

All of the NRI have projects planned for Phase III. Cooperation/interaction with actors have already started and in some cases sites have been picked out.

The PI points that the ARRPET part in Phase III will still be research, i.e. design and initial monitoring/trouble shooting of the plants. The cooperation partners have responsibility for (contracts for) construction and operation of the plants.

Networking

The SWLF group has actively worked to develop and improve networking skills since the start of ARRPET/Phase I. An objective for networking was included in the LFA matrix, together with measurable parameters and sources of verification.

Objective for Networking among NRI:

Compilation of existing practices of solid waste management and basic information about solid waste organization, anthology of training materials, lecture notes, workshop and training programs.

Measurable and indicators

- Per country 4 issues identified.
- Per country 2 cities or locations considered for detailed case studies
- Per country once a year interaction with stakeholders.
- Per country 20 persons trained on relevant SWM matters
- At least one mutual exchange of researchers between NRI per year

The Annual Review meeting (AR) is the basis for networking with the ARRPET project. Trough presentations of research progress the whole ARRPET-group is informed of activities in the other projects and cooperation between projects can be developed. So far the exchanges with NRI from other projects have been minor. CES has work together with the Air Quality-NRI in Chennai on landfill emissions.

In addition a national workshop is held ca 6 months after the ARW. All NRI come to the national workshop and stakeholder/actors for the given workshop theme are invited. The team will have a separate meeting to discuss research progress and administrative matters in connection to the national workshops. The NRI take turns to organize the national workshop (with help from AIT). Reports from national workshops are disseminated to participants and other interested parties. The latest was held in September 2007, organized by CES in Chennai, India. Due to the current problems with collection of MSW (change of entrepreneur) the workshop got a lot of (positive) attention in media.

It is difficult to pool resources for laboratory analysis between NRI, as waste cannot be transported freely across boarders. However, all NRI have access to laboratories facilities and the equipment they

need. Kasetsart and AIT can pool their resources and some of other NRI cooperate with other departments at their university. There has also been exchange of students/staff between NRI for training and the group is working on preparing a common/joint laboratory manual. Parts of the manual are already available, in a working document, and used by the individual NRI.

The PI actively promotes joint publications to promote networking and produce "stronger" articles (both in scientific quality and language).

There is a potential to increase the cooperation between the different projects in ARRPET. In some cases they work on related issues and an increased cooperation could further strengthen the research capacity. However, all the projects have set up objectives, outputs and outcomes in relation to the time and resources available for their project. For the feasibility of these studies it may not Taking on new tasks, such as cooperation between projects may take be a constraint.

Dissemination

Knowledge dissemination from ARRPET project was conducted at multiple levels.

- The technology developed was published in peer-reviewed journals and were presented at national and international conferences. For number of papers and distribution between see Table 2. In addition some manuscripts are ready but not yet accepted for publication.
- A total of 66 papers have been presented at international conferences. In addition 15 papers have been presented at national conferences. (Table 2).
- The NRI have organised 4 workshops in order to keep the stakeholders and policy makers informed about the research developed (promote networking among NRI, i.e. national workshops and others).
- Short training courses and seminars (Regional Guidelines for Sustainable Management of Municipal Solid Wastes in Asia)

Table 2. Publications Phase I and II: Journals and conference papers.

Paper category		Phase I & II					
		China	India	Sri Lanka	Thailand	AIT	Total
International Journal	Individual	1	8	-	5	4	18
	Joint		1 (Th)	2 (AIT)	3		7
				1			
National Journal		13	5	5	3	3	29
Conferences		5	21	12	16	26	80
	International conference Channel	1	3	3	3	1	12
		1					
	Joint- International		1 (AIT)		1 (In)		17
				1		1(SL) 1 (In)	
			1		1(In)		
			2 (AIT)		3		
			1				
		4					
	National	1	12	1	1		15
Books							3
Book Chapters							5

- Many of the
- The work of NRI and ARRPET has also been described in media (national and local newspapers, television, radio). The PI has been interviewed in Readers Digest.

For more on publications see Table 2 and the SWLF home page: http://www.swlf.ait.ac.th/NewInterface/ProjectPublications.htm

Capacity Strengthening

Capacity strengthening activity was mainly targeted towards strengthening technical manpower. To this end, most of the NRI had large success by guiding Masters and Ph.D. students as part of the project activity.

Several MSc and PhD students have been educated/gotten their degree (partially) within the ARRPET project. Also the project has contributed to training research staff (that in, the cases they have moved on to other organizations are often till working in the field they were trained by ARRPET)

Only the part of the students' work that was related to ARRPET was financed by the project.

Books purchased with ARRPET funds are used as a common resource. AIT has lists of all the books at each NRI. The project has also compiled a joint collection of references.

Some laboratory infrastructure was built from the funding of Minor Equipment in the project.

Administration

The administrative structure of SWLF project consist of a Principal Investigator (PI) designate from amongst the NRI whose duty is to

- monitor the NRI projects on a regular basis in consultation with a Swedish expert,
- give timely feedback to the NRI,
- enforce the project requirements and
- prepare the project reports.

Prof. C. Visvanathan at AIT has been PI for the SWLF project since the start (of Phase I). During the first three years he was supported by a guest researcher at AIT (Dr J Tränkler from Germany, GTI). The PI also handles financial matter.

Budget and finance

Each NRI sends a proposal for necessary funds to PI (based on the activities the group has decided on). Funds are distributed (by AIT steering group), more or less even, with minor adjustments based on these.

Funds are made available to NRI when they have completed their reporting obligations (as decided in the LFA matrix for Phase II). NRI report no specific problems with delays in payment.

According to the Terms of Reference the budget can/must be spent on the following seven line items: Minor equipment, Literature, Consumables, Field work, Personals, Regional networking and Unforeseen. There are certain limits to how large part of the total budget can be used for each line item.

These terms have been seen/used as a way to monitor spending and were therefore not considered a problem for carrying out planned activities.

Funding for the pilot plant construction, operation and maintenance were secured from private partners in most cases. Cost Benefit Analysis (CBA) was conducted by each of the NRI for their respective projects.

Monitoring/Internal review

The initial NRI (from China, India, Sri Lanka and Thailand) as well as the PI has remained in the project since Phase I. The NRI all answered a "Call for interest" from AIT[13] and were chosen according to set criteria. During the first three years the PI was supported (and mentored) by a German guest researcher at AIT (Dr J Tränkler).

The Annual Review workshop and the LFA matrix are the basis for monitoring the progress of research, use of funds and administrative details. NRI must deliver progress reports, including financial report, according to set parameters some weeks before the ARW. The report is read and commented by PI. The PI will for example remind NRI that not funds for equipment and literature cannot be used during the last part of the project. If needed NRI get a chance to comment and/or give justifications for e.g. deviations from objectives/outputs in the LFA. All communication in regards to the progress report is handled via e-mail (i.e. saved in writing)

Funds are made available/paid to respective account when the progress report is approved. So far there have been no major delays in payment (and none that effected research capacity).

The combined Review report for the whole theme can be found on ARRPET home page www.arrpet.ait.ac.th/SolidWaste/SWLF-ARRPET_2_Evaluation__Combined_FINAL.pdf

Compilation of Questionnaires

Method of interpretation

The replies by each NRI have been compiled below in the form of a scoring system; 1–5 representing as below:

1. not achieved
2. almost achieved
3. achieved
4. successful
5. very successful

The scoring builds on compilation of the results from each NRI, meetings with the team leaders and many of the students. Such a scoring method is used to try to facilitate the understanding for the reader but will be subjected to the evaluator ability to interpret correctly the replies. The evaluator urges that she made her best in being objective and open-minded, but obviously the scoring is subjective. The reviewer claims that the method still gives a good rough view of the actual situation.

The scoring represent and average of all NRI. If the variation is large among the NRI a range of scores has been presented.

Questions	Score	Comment
Quality and relevance to the Asian region of research within the ARRPET frame, with focus on hard science and technology		
Scientific methodology		
Literature review, knowledge of the status of science. Where initial literature reviews done and the knowledge implemented into the project?	4	Literature reviews were carried out at the beginning of Ph I & II. Some published as ARRPET reports.

[13] Except for the Thai-NRI that at a relative late stage in the selection process replaced Vietnam.

Questions	Score	Comment
Formulation of objectives. Where objectives spelled out at the NRI level? Did the NRI contribute to theme objectives?	4	Objectives were formulated in initial LFA workshop. All NRI participated.
Formulation of hypothesis. Where research based on hypotheses?	3–4	They were there but not stated. Initially a large share of descriptive research.
Research plan – Experimental design, field design of trials relevance of location and methods for data collection	4	Design, location and methods relevant to local context.
Evaluation of data, statistical data analysis when appropriate	3	
Scientific results		
Has high quality scientific results been generated?	3–4	See list of publications
Has scientific results been generated which are relevant to the Asian region and which has focused on hard science and technology?	5	Good knowledge of the current situation and the issues that needed to be addressed.
Has the scientific results generated been relevant for, and have had an impact on, national and regional initiatives for policy plans controlling urban and environmental pollution?	4	Relevant and communicated to decision makers/practitioners
Feasibility and relevance		
Researchers' training and research experience related to the projects	4–5	
Rationale for the research; analysis of problems; and identified beneficiaries	5	
Feasibility of the project in relation to time and resources	3–5	Objectives according to LFA matrix mainly met. Some results remain to be published.
Consideration of environmental and safety aspects	4	Not optimal in all cases, but compared to existing practices all suggested changes will be improvements.
Likelihood of results to be applied	4–5	Some already applied. Good contacts with decision makers/practitioners.
Relevance of results to scientific advancement	4	
Relevance of results to national priorities	4–5	NRI have participated in developing national priorities.
Relevance of results to socio-economic conditions	4–5	

Questions	Score	Comment
Mobilisation and strengthening of competence and capacity in the National Research Institutions (NRI) participating in the ARRPET Programme, in conducting research relevant for controlling urban and environmental pollution, and in relation to national and regional initiatives and policy plans		
Gender balance and equity		
Percentage of researchers of each sex, and total number of researchers participating at each NRI	3	Gender balance among students but not among leaders
Did the scientific results take into consideration gender and equity, when appropriate?	NA	
Scientific capacity strengthening		
Composition of NRI research team, and changes over the years considered, with regard to academic degrees	4	
Has a critical mass of researchers been established at NRI	3–5	Some NRI dependent on students and/or other NRI.
Are researchers outside ARRPET contributing to critical mass at NRI	2–4	
To what degree have the NRI activities contributed to capacity strengthening at regional level?	4–5	
Has NRI team members left to be employed/take up studies elsewhere	5	
Has the leaving of researchers affected regional research capacity	5	
Networking		
Communication between researchers at each NRI	4–5	Regular and "informal" meetings.
Communication between NRI	3–5	
Continuous overview of the NRI activities by AIT (addressed to ARRPET Coordinator)	5	
Overcoming varying scientific infrastructure and scientific tradition at NRI	4	
Experts from Sweden; input, influence, impact	5	Cooperation outside ARRPET
Researchers links with policy makers; contacts, influence, impact	4–5	Explicit objective in LFA matrix
Overcoming varying level of cooperation among governments in providing data to the researchers. To what extent has this been a problem?	4–5	All NRI say govt. provide data "when available". The problem is availability. Gov's and NRI cooperate to fill the gaps.
Create links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas	4–5	
Networking outside ARRPET to the benefit of ARRPET theme activities	5	
Support from AIT to research institutions		
Has AIT supported in general management at Theme and NRI level?	4	
Has AIT supported in administration at Theme and NRI level?	4	
Has AIT supported in coordination at Theme and NRI level?	4	
Has AIT supported in scientific supervision at Theme and NRI level?	4	Not perceived as part of mandate

Questions	Score	Comment
Has AIT supported in project management at Theme and NRI level for the Running projects in actual practice?	4	
Has AIT supported in the functioning of the Steering Group?	NA	Contacts with AIT via PI (Terminology: some NRI consider the Solid Waste group as steering group)
Importance of Annual Review Meetings to Themes and NRI?	5	ARW is the basis for networking and monitoring of progress
Spin-off projects: the importance of these?	4	
Achievement of goals		
At the beginning of the project a Logical Framework Approach (LFA) matrix was made for each subject matter area as well as for the program as a whole. The LFA lists objectives, expected results, activities, assumptions and indicators. Where the objectives met? Which outputs were generated? Output is defined as: "the products, capital goods and services which result from a development intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes [15]" Which outcomes were achieved? Outcome is defined as "the likely or achieved short-term and medium-term effects of an intervention's outputs [15]" Achievements in relation to the logical framework approaches developed July 2000 at AIT meeting Develop technical solutions adapted to local conditions Formulate policy recommendations for these solutions Strengthen existing research capacity in the region Disseminate the research results, academic as well as technical	NA	Objectives, outputs and outcomes formulated in LFA matrix. With few exceptions met/ generated. See Review report on home page. Planning, monitoring and (annual) follow up according to LFA matrix. Minor changes.
How has the collaboration with EEPSEA which performs environment-financial analyses been?	1	NRI have not cooperated with EEPSEA
What was achieved in relation to Environmental Impact Assessment (EIA) that was presented in AIT project proposal?	4	Each NRI have produced at least one (initial) EIA report
Dissemination of results of the programme among policy makers and the possible impact on environmental policy (locally, regionally and nationally)		
Dissemination of results		
Local peer reviewed journals	4–5	
Global peer reviewed journals	2–5	Se table of publications.
Reports addressing technicians and end-users in actual practice	4–5	
Reports addressing policy makers, easy-read synthesis report in order to influence policy making	4	
Reports addressing product developers	NA	
Seminars	4–5	Policy makers, practitioners, short courses, participation of all NRI, media invited
Implementation of results		

Questions	Score	Comment
Where technical solutions to environmental problems suitable for local conditions developed?	4–5	
Where policy recommendations based on such technical solutions to environmental problems suitable for local conditions provided?	4	
Where science, technology, financial aspects and policy integrated?	4	
Did the project contribute to strategically environmental friendly production	NA	
Finance		
Did NRI have an influence on fund allocation between NRI?	2	See Budget and finance
Has funds been distributed in a way that has not hindered the activities at NRI?	4	
What is the proportion of ARRPET financing in relation to the overall financing of your research in the specific areas?	NA	ARRPET stands for 60–90%
Would certain research project not have been realized without ARRPET financing?	NA	Yes
What will happen to your research in certain areas if ARRPET financing will not be provided for the discussed Phase III?	NA	Some research projects/ implementation can be carried out, but not the networking.
Would you rather like to use potential funding for the discussed Phase III in some other way than just for a continued/enhanced research work in specific areas?	NA	PhD students
What are the co-funding options for the future?	2–3	Cooperation with e.g. municipalities and private companies.

C. Improving Air Quality (AIRPET)

Foreword

The evaluation and comments are merged from the reviews, discussions, and follow-ups accomplished by the RP and the Evaluator. The evaluation is made against the objectives and expected results for the program, the Compilation of Questionnaires and the discussions with the various people at the NRs, the PI at AIT, and formal reports are the basis for the evaluation and comments (please see Appendix 4).

Purpose

Rapid urbanisation and industrialisation with the concomitant soaring increase in energy consumption in Asian developing countries have brought about increasing numbers of air polluting sources. The development of infrastructure, environmental technology and management practices does not keep pace with the emission increase, which results in a progressive deterioration of air quality. To address the lack of background data, appropriate control technologies, sound management strategies as well as human and financial resources, which are essential for improving air quality, the following issues are in focus:

- monitoring for toxic and organic air pollutants,
- appropriate air pollution control technologies, and
- modeling tools for integrated air quality management.
- integrated air quality management for target sources (added with Phase II)

[15] Molund, S and Schill, G (2007). Looking Back, Moving Forward. Sida Evaluation Manual, 2nd revised edition, Sida, Department for Evaluation and Internal Audit, Stockholm, Sweden.

The proposed research is conducted jointly by the AIT, Thailand, and five other National Research Institutions (NRI) from Asian countries; namely China, India, Indonesia, Philippines and Vietnam.

Organisational Structure

See http://www.serd.ait.ac.th/airpet/main_research.htm

Subprojects

The following, descriptive part is a summary of information provided by the PI of AIRPET. The evaluation assessment is compiled in the Questionnaire section of this Annex, and in the main document, section 5.5.4.

Monitoring of toxic air pollutants and particulate matter source apportionment

PM mass concentration and composition

Monitoring for fine and coarse particles has been conducted continuously in all 6 cities, i.e. Bangkok, Beijing, Chennai, Bandung, Manila, and Hanoi. This has created a long-term monitoring record of fine (PM2.5) and coarse (PM10-2.5) particulate matter mass concentration and composition (continued from phase 1) to detect the temporal variation.

Among the six cities, the mass concentrations of PM10 and PM2.5 are found highest in Beijing, especially during dust storm periods. PM2.5, which is more toxic, almost always exceeded the WHO 24h PM2.5 guideline of 25 mg/m3 in all the cities during the dry season. During the wet season the frequency of exceeding the guideline is still high in most of the cities.

All PM samples were analyzed for mass concentration, chemical compositions including 8 water soluble ions, black carbon (BC) and elements using the equipment made available by NRI.

The variation in PM composition between day and night, between dry and wet season, between polluted days and cleaner days, and between the urban sites and the remote sites helps to understand the different emission sources and formation mechanisms of urban PM pollution in these cities. Higher concentration of PM during dry season is linked to increased intensity of emission sources (biomass burning, soil re-suspension, construction activities) and meteorological conditions that lead to more stable atmosphere, less wet removal and more secondary PM formation.

Toxic pollutants

Semi-VOC (POP: PAH, pesticides and PCB in PM and gaseous phase, 76 samples) were monitored at road sites in Vietnam (BTEX, 500 samples). The levels of BTEX and PAH were found higher at the urban sites, especially the road sites, than the remote sites which may be due to more open burning and gasoline related emission around the cities. Other gaseous pollutants such as SO2, NOx and O3 were monitored in Chennai (374 samples) where the data from the city monitoring network was not available. The results show that the gaseous pollutant levels in Chennai were still lower than the national ambient air quality standard.

To ensure the data quality, QA/QC procedure has been established and implemented by all NRI in the network. A database template was designed and used for all AIRPET to achieve the harmonization in data presentation and analysis. Several types of blanks were analyzed including the trip blanks, laboratory blanks, solvent blanks and all analytical results were corrected for blanks.

New findings: Traditionally, most of Asian developing countries monitored only large particles (total suspended particles, TSP) and only some cities started monitoring PM10. The AIRPET project is believed to produce the first long-term systematic PM mass and detail composition data, for both fine and coarse fractions, in the Asian cities.

Receptor modeling

The obtained PM composition data at all monitoring sites were analyzed by receptor models to quantitatively identify the contributing sources. Two models are used commonly by all NRI: Chemical Mass Balance (CMB) and Positive Matrix Factorization (PMF) with source profiles mainly from literature. The source apportionment results indicated that diesel vehicles, secondary PM and biomass/refuse burning are the main contributors to PM2.5 in the cities. For coarse particles (PM10-2.5) the main contributors are re-suspended airborne soil/dust and construction activities.

New findings: The receptor model results revealed the biomass burning as a major PM source in all the cities, which was largely overlooked in the air quality management. The systematic data produced by this project provides the scientific basis to recommend the minimization of open burning as the agroresidue disposal method.

Emission sources characterization and PM source profiles development

The emission characterization was done for the major PM sources identified by receptor modeling. Thus, the emissions from diesel vehicles (AIT, Indonesia by chassis dynamometer), biomass open burning (AIT, Philippine), 4- and 2-stroke gasoline motorcycle vehicles (Indonesia by chassis dynamometer), and coal fired boiler (China) have been monitored to determine the source emission profiles (for receptor modeling) and emission factors (for emission inventory and dispersion modeling).

New findings: This activity produces the first comprehensive detail source profiles for major sources in the developing countries in Asia, which include not only ionic, elements and BC/EC and OC species, but also other organic source markers such as PAHs. The data are useful to improve the receptor modeling results.

Exposure monitoring for health effect study

Measurement of blood lead level (BLL) in school children of Bandung, Indonesia, was done. Approximately 400 blood samples of school children were collected from selected schools. The mean value of BLL was 14 mg/dL and 65% of children have BLL values above 10 mg/dL (WHO standard for children under 12 years old). IQ tests conducted for 150 children indicated a negative correlation between BLL value and IQ points. Leaded gasoline used in vehicles before 2006 was the major source of the lead pollution in the ambient air.

New findings: High BLL in school children in the Bandung city effectively called for phasing out of leaded gasoline in Indonesia.

Dispersion modeling

A number of 3D complicated models have been applied including model3-CMAQ (AIT), CAMx (AIT, Vietnam, Philippine), and CHIMERE (AIT) in couple with MM5 (meteorological model). Other types of models such as ISCST (for brick kilns in Vietnam) were also used.

Application of CAMx-MM5 for ozone air quality in Manila is being investigated.

Ozone modeling by UAM-V and CAMx-MM5 was done for Hanoi using the emission inventory developed by Vietnam NRI for this purpose. ISCST was used for modeling impacts of brick kiln emission for emission reduction scenarios study.

Development of flue gas emission control technology

A few lab-scale control technologies were developed during phase 2 including the devices for VOC control (China), NOx control (India), and NOx/CO control (Indonesia).

Catalysts Pd/Ln-SBA-15 for removal of benzene, toluene and xylene emissions were developed in China which showed a good performance for the full elimination of benzene at 200ºC. The catalytic system has also been applied to control chlorine-containing VOC, which are more difficult to be removed. Both Mn and Co are promising catalytic materials for the control of chlorine-containing VOC.

The NRI in India developed a novel and effective system for complete treatment of NOx from flue gases using photocatalytic (TiO2) or ozone oxidation of NOx, followed by scrubbing and biological denitrification.

A new multi-plate reactor with bigger size and larger plate spacing to eliminate NOx gas from coal combustion and vehicle exhaust was developed in Indonesia, which achieved 83% and 78% removal efficiency, respectively. When applying for CO removal much lower removal efficiency was observed (40%).

New findings: The control devices are newly invented with the optimum designing and operating variables investigated. They are ready for pilot scale applications.

Integrated management strategies for target sources

Target sources selected for AIRPET include open field rice straw burning (AIT), brick making community (Vietnam), VOC emission (China) and vehicle exhaust focusing on leaded gasoline (Indonesia). Integrated measures including monitoring for air pollution and health effects, modeling for management scenarios study, application of control devices to remove air pollutants, as well as community participatory approach were applied to reduce the sources emission. This aims to provide a showcase which could be multiplied in other places.

In Indonesia the target source was vehicle emission reduction focusing on unleaded gasoline. The activities include the vehicle emission monitoring (source profiles and emission factors for 2- and 4-stroke motorcycles and diesel vehicles), and monitoring for blood lead levels and IQ tests for school children. The results were provided to the policy makers to speed up the phasing out of leaded gasoline.

In China the VOC emission management was conduced for the paint and coatings sector. A consolidated report on the integrated management of VOC control in this sector in China has been completed with recommendations on policies for sustainable and environmentally friendly coatings. A preliminary cost benefit analysis for VOC catalytic combustion was made.

In Vietnam a polluting brick making community (Song Ho, Bac Ninh) was selected for implementation of integrated management strategies. Kiln stack emission monitoring and ambient air quality monitoring were conducted and a modeling tool (ISCST) was applied to estimate the impact of kiln emission on ambient air quality. A control device (lime wet scrubber) was designed and is tested for optimum operating conditions to achieve required control efficiency. The installation and future operation of the device involves close participation of the kiln owners and local authorities. A workshop is planned in 2007 to discuss the findings with key local governmental organizations and other stakeholders.

New findings: Target sources have been identified as the open issues from phase 1. All the research activities related to the integrated management strategies are new for the countries. The approach and results gained can be multiplied and transferred to other NRI where similar situations present.

Applications of research results

All the research results are based on the real life conditions; hence they are readily useful for the real life applications. The results are relevant and reliable scientific information for policy making. In particular, the time series data on fine and coarse PM mass concentrations provide information on warningly high PM levels during the dry season in each city that can be used to raise the concern on the potential cost of air pollution due to health effects. Other data collected on emission inventory, deposition velocity

and fluxes are used as region-specific relevant input for dispersion modeling to develop realistic management strategies.

Major sources of PM pollution identified by source apportionment study (diesel vehicles, biomass burning, etc.) serve as the basis for scientific recommendations to prioritize sources for abatement. Capacity enhanced within the AIRPET enables NRI to get spin-up projects funded by other donors.

The built-up expertise helps the researchers to be recognized as the local champions and they are invited to serve as members of different national/local committees and can be directly involved into the policy making process. The methodology, models and database developed by the project are disseminated to local and regional researchers through training and research seminars for capacity building. In addition, 3 pilot scale treatment processes were installed and in operation.

China NRI: The team emphasizes on the need for national PM2.5 standards. Measures for particulate matter pollution reduction are recommended. NRI Team Leader is the Chief of Committee for Waste Gas Treatment of China Environmental Protection Industries and a member of many national committees to directly involve in policy making.

India NRI: The NRI provided scientific information to the State Tamilnadu Pollution Control Board. The Team Leader serves as an expert committee member for the Tamilnadu Pollution Control Board on toxic and hazardous materials.

Indonesia NRI: The results of high blood lead level in school children and a reduction of IQ points were used as a driving force to phase out the leaded gasoline in the country. Since September 2006, the city of Bandung as well as other cities in Java has been free from leaded gasoline. Results of this study are also used by the local government as scientific evidence to develop the Ambient Air Quality Standard for West Java Province. The Team Leader has been involved in the development of local standards.

Philippine NRI: The NRI (Manila Observatory) became a service provider for the "Air Care Program", a community-based air quality management strategy implemented by the Miriam ESI and the Energy and Clean Air Program (ECAP) of USAID. The NRI also participated in the Co-benefits of Climate Change Mitigation (EPA-funded) project as a coordinator in Asia.

Vietnam NRI: The research results from brick manufacturing commune have been discussed with the key local governmental organizations, i.e. the governmental offices in Bac Ninh, department of Natural Resources and Environment, and People Committee of Thuan Thanh District (Bac Ninh) to create the awareness on air pollution issues. NRI Team Leaders are involved in various national committees to review air quality standards.

Networking

Within AIRPET

The intensive networking has been developed consisting of e-mail communications, idea/information exchange over the internet, and joint publications. The website (www.http.serd.ait.ac.th/airpet) operated by AIT keeps all NRI informed about events and project documents.

Exchange program for researchers from NRI (3 from Vietnam and 1 from Philippine) to AIT was implemented. The AIRPET project organized a workshop-cum-training in Bali (September 2006) and annual review workshops every year. A joint publication was published and 2 more are planned.

With other projects in ARRPET

Cooperation with solid waste project is established to explore the impacts of solid waste disposal on air quality by India NRI. The impacts of burning of agroresidue waste (AIT) and refuse burning (Philippine) on air quality are studied to promote non-burning alternatives.

Local partners

Several NRI teams are composed of two national institutions, which provide basis for collaboration at national levels (China, Vietnam). The NRI also actively communicate with the municipal and state/national environmental authorities (EPA, DOSTE, DoNRE) for information/data exchange and data/instrument sharing.

International partners

A network with international organizations and programs has been established. This is particularly important for air pollution research as there are only a few researchers in the region and the NRI PI are frequently contacted for information sharing and collaboration. In particular, a close links with the Clean Air Initiatives for Asian Cities (CAI-Asia) have been established due to the nature of AIRPET project that are integrated well in the agenda of CAI-Asia.

Dissemination

Website

The AIRPET website (http://www.serd.ait.ac.th/airpet/) is regularly updated to provide the information exchange within and beyond the AIRPET team.

Workshops organized

- AIRPET organized a project workshop in Bali, Indonesia, September 2006.
- AIT team co-organized (with the SEA-UEMA) a dissemination workshop "Knowledge Transfer for Reducing Air Pollution from Agricultural Residue Open Burning" for local farmers and local authorities (June 2007, Nonthaburi, Thailand).
- Vietnam NRI organized a national dissemination workshop on July 30, 2007.

Publications

Up to now the AIRPET team has produced 43 peer-reviewed journal articles, 47 peer-reviewed papers in international conference proceedings and conference presentations. There are also 20 manuscripts being prepared from the research results. The full list of papers is presented on the website (www.serd.ait.ac.th/airpet/main_publications.htm).

The results generated in the AIRPET phase 2 were disseminated in the policy dialog "Urban Environment Management Policy Dialog" in Hanoi, Vietnam, November 2005, and at other local and international seminars, conferences. The dissemination through media such as national TV and national news papers (Indonesia NRI team) was done to raise public awareness. AIRPET project profiles were published in the CAI-Asia compendium, available at www.cleanairnet.org/caiasia/1412/article-70670.html.

Capacity Building

Manpower: technical trainings and students, post-docs, research staff

Several trainings were organized by the team during Phase II. AIRPET provided a two-day training course on receptor modelling in Bali, Indonesia (Sept. 2006). AIT conducted training on photochemical smog modelling, BC measurement, and receptor modelling for the NRI staff. Researchers from AIRPET team also participated in other international trainings organized at AIT (UNEP-ABC, UNEP-Male, WB-Distant learning, etc.). In addition, various hands-on trainings were offered on equipment operation, data analysis methods, modelling etc. within each NRI.

Phase II involved 13 research associates (3 from AIT, 1 from China, 3 from India, 3 from Philippines, and 3 from Vietnam) and 1 research engineer from AIT for every-day project operation. Students are involved by taking the thesis research related to the project activities. Most of them served as the stu-

dent assistants. Totally, the AIRPET phase II involved the following number of students at three levels. Most of Master and Undergraduate have already graduated with the degrees.

- 7 Undergraduate
- 43 Master
- 9 Ph.D.

The following laboratory equipment were purchased or designed to use in the project:

- PM samplers: 6 mini-volume samplers, 2 PEM, 1 optical particle counter (OPC), 1 cascade impactor, 1 dust samplers
- Gaseous online measuring instruments: 2 CO/CO2 analyzers (IAQ-CalC)
- Analytical equipment: 1 Ion Chromatography, 2 Microbalances
- Computers and software: 4 PC to form a cluster for running complicated CMAQ-MM5 model system, ISC3 software
- Others: 4 personal pumps, 4 dehumidifiers, 1 chiller, 1 air condition unit for microbalance, 1 meteorological station
- Equipment designed: a deposition sampling system, indoor air pollution sampling device for semi-VOC, a calibration tube for dichotomous samplers
- Equipment under acquisition: meteorological mobile station, EC/OC SUNSET analyzer (AIT, with partial funding from other projects)

Compilation of Questionnaire

Method of interpretation

The replies by each NRI have been compiled below in the form of a scoring system 1–5 representing:

1) Not achieved
2) Almost achieved
3) Achieved
4) Successful
5) Very successful

The scoring builds on compilation of the results from each NRI; meetings with the Team Leaders; other persons related to the project like previous Team Leaders; rectors; researchers; government officers; and many of the students. Such a scoring method will obviously be most subjective but should anyway give a reasonable indication of the actual situation. When scoring is not relevant comments are made instead.

The scoring represents an average of all NRI. The variation between the NRI is in some areas large. In these cases a range of scores has been presented. Comments are made when appropriate.[15]

[16] This evaluator used an earlier version of the Questionnaire.

Question	Score	Comment
Scientific methodology		
Literature review, knowledge of the status of science? Where initial literature reviews done? Covering which area? How were they used?	4	
Formulation of objectives? Where objectives spelled out at the NRI level? Did the NRI contribute to theme objectives?	3	The objectives were spelled out in close cooperation with the PI though not always coordinated.
Formulation of hypothesis? Was research based on hypotheses?	3	
Research plan? Experimental design? Field design of trials? Relevance of location and methods for data collection?	4	Coordinated with PI but seldom with other NRI.
Evaluation of data? Statistical data analysis?	4	Often reviewed and coordinated with PI.
Scientific results		
Generation of high quality scientific results as can be estimated by publication/dissemination profiles based on lists of publications including conference contributions, and their impact (journal impact factors considered)?	2–5	Large variation between NRI.
Good quality research relevant to Asian region with focus on hard science and technology?	5	
Conducting research into national and regional initiatives for policy plans, controlling urban and environmental pollution?	3–5	Large variation between NRI.
Feasibility and relevance		
Researchers' training and research experience?	4	
Rationale for the research; analysis of problems; and identified beneficiaries?	5	
Feasibility of the project in relation to time and resources as mentioned in the ToR?	4	Still remaining work to fulfil the objectives of phase 2.
Consideration of environmental and safety aspects?	4	
Likelihood of results to be applied?	3	Some pilot plants show a good potential.
Relevance of results to scientific advancement?	4	
Relevance of results to national priorities?	4	National priorities are there but it is in some cases hard to push the research results through to decision makers.
Relevance of results to socio-economic conditions?	4	
Gender balance and equity		
Percentage of researchers of each sex, and total number of researchers participating at each NRI?		As an average around 60% of the researchers are female.
Did the scientific results take into consideration gender and equity, when appropriate?		No.
Scientific capacity strengthening		

Question	Score	Comment
Mobilize and strengthen the scientific capacity at National Research Institutes? Composition of NRI research team, and changes over the years considered, with regard to academic degrees?	4	Large variation between NRI.
Strengthen research capacity in the region? To what degree have the NRI activities contributed to this? Has NRI team members left to be employed/take up studies elsewhere? Has this affected regional research capacity?	4	Most researchers have moved to other academic institutions; some to public offices; and many undergraduates have routine work in private sector (industries). The impact on research capacity is limited.
Networking		
Communication between researchers at each NRI?	4	
Communication between NRI?	2–4	Some NRI cooperate on various levels.
Continuous overview of the NRI activities by AIT?	4	The PI overviews the activities in detail.
Overcoming varying scientific infrastructure and scientific tradition at NRI?	2	Limited cooperation between NRI.
Experts from Sweden (use, input, influence, impact)?	2–5	Highly appreciated support when available but the time allocated has been too limited.
Researchers with policy makers (contacts, influence, impact)?	2–5	Large variation between NRI.
Overcoming varying level of cooperation among governments in providing data to the researchers? To what extent has this been a problem?	2	Limited cooperation between governments; other regional networks (Isuch as the Clean Air Initiative for Asian Cities; www.cleanairnet.org) overbridges some weak areas.
Create links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas?	1–4	Some NRI are active in national networks.
Networking outside ARRPET to the benefit of ARRPET theme activities.	3	
Support from AIT to research institutions		
Management? Has AIT supported in general management at Theme and NRI level?	4	
Administration? Has AIT supported in administration at Theme and NRI level?	4	
Coordination? Has AIT supported in coordination at Theme and NRI level?	4	Most coordination goes via AIT as a hub.

Question	Score	Comment
Scientific supervision? Has AIT supported in scientific supervision at Theme and NRI level?	4	
Running projects in actual practice? Has AIT supported in project management at Theme and NRI level?	3	
Establish "critical mass" of researchers at NRI? Is a critical mass of researchers achieved at the Theme and NRI level? Are researchers outside ARRPET contributing to critical mass.	2–4	Large variation between NRI.
Steering group? Are steering groups established at Theme and NRI level. Roles and function?	3	The Annual Meetings function as decision-making bodies.
Annual Review Meetings? Importance to Themes and NRI?	4	
Spin-off projects?	2–4	Some commer-cialization projects have been established at some NRI.
Achieving goals		
Outcome?	3	
Outputs?	3–4	Large variation between NRI.
Objectives met?	3–4	
Achievements in relation to the logical framework approaches developed July 2000 at AIT meeting?		
Develop technical solutions adapted to local conditions?	3–4	
Formulate policy recommendations for these solutions?	2–5	Large variation between NRI.
Strengthen existing research capacity in the region?	4	
Disseminate the research results, academic as well as technical?	2–4	Large variation between NRI.
Collaboration with EEPSEA which performs environment-financial analyses?		No NRI has any contacts with EEPSEA
Achievements in relation to Environmental Impact Assessments that were presented in AIT's project proposal?		
Dissemination of results		
Local peer reviewed journal?	2	Limited resource base to find peers locally.
Global peer reviewed journal?	2–5	
To technicians and end-users in actual practice?	2–5	Government agencies have shown interest in some cases; in some the capacity is so limited at the receiving side.
To policy makers?	2–5	Limited interest from receivers. In some cases the positive opposite.
Product developers?	3	Development potential.

Question	Score	Comment
Dissemination of policy oriented, easy-read synthesis report in order to influence policy making?	1–5	Some NRI are very media/decision makers oriented; some not at all.
Seminars?	3–4	
Implementation of results		
Development of technical solutions to environmental problems suitable for local conditions?	2–4	Large variation between the NRI. Big potential for commercialization of results in some cases.
Development of recommendations for policy development for such solutions?	2–4	Large variation between NRI.
Integration of science, technology, financial aspects and policy?	2–4	Large variation between NRI.
Develop policy recommendations based on technical solutions to environmental problems suitable for local conditions?	2–4	Large variation between NRI.
Contribution to strategically environmental friendly production?	2–4	Large variation between the NRI.
Finance		
How has funds been allocated between NRI?		According to requests (not evenly distributed).
Did NRI have an influence on allocation?	3	If an NRI would like to accomplish a project outside the main stream, the allocation was limited.
Have funds been distributed in a way that has not hindered the activities at NRI?		Budgets are generally too limited…
Co-funding options?	2–5	Some NRI have significant co-financing from public (and sometimes also private) funds; some no other funding
What is the proportion of ARRPET financing in relation to the overall financing of your research in specific areas?		Varies from a fraction to 100%.
Would certain research project not have been realized without ARRPET financing?		Yes!!!
What will happen to your research in certain areas if ARRPET financing will not be provided for the discussed phase 3?		These projects must more probably be stopped.
Would you rather like to use potential funding for the discussed phase 3 in some other way than just for a continued/enhanced research work in specific areas?		Some NRI would like to move into more application type projects; others like to continue basic monitoring.

D. Industrial and Hazardous Waste Treatment and Management

Foreword

This compilation of the projects builds on a questionnaire addressed by all PI as well as the outcome from meetings with the team leaders, the teams and visits to pilot plants.

Purpose

The main goal of the Industrial and Hazardous Waste Treatment and Management (IHWTM) is to engage in research on industrial and hazardous waste-related issues relevant to Asia, in particular:

- removal of AOX from pulp and paper industries,
- removal of heavy metals from industrial wastewaters, and
- degradation of PCBs

Organisational Structure

The following six NRI are involved in this subject matter area. Data about staff and students are provided by the NRI and given as example when at hand.

Agharkar Research Institute (ARI), Pune, India

ARI is an autonomous research institute that receives core funding from the Ministry of Science and Technology. ARI undertakes contract research in animal sciences, microbial sciences and plant sciences. The institute is regarded as a centre of excellence for biological treatment of industrial waste water.

Team Leader: Dr. D. R. Ranade. Presently, two researchers (Dr. D.R.Ranade and Dr. P K Dhakephalkar) work on the project, together with two PhD students (Kuahsal Lapsiya and Nitin Deshmukh, both male) and a laboratory technichian (Ms Sonia Dhage). Dr T Y Yeole and Dr A M Mujumdar are associated.

One female researcher (Dr Ms D V Savant) worked from January 2002 to September 2007. Then she left to join as the Lecturer in one of the colleges in Mumbai. Other RA Dr K K Meher (male) worked from March 2006 to February 2007. He then took a post at the Institute as Research Scientist. To other PhD students have been attached to the project, Ms. Manjiri Karandikar (March 2002 to March 2003) and Ms. Arati Shingte (March 2002 to Sept 2003) but have left for various reasons.

The gender ratio of researchers employed for the project is 2/3 Male and 1/3 Female, which is atypical for microbiology in India, otherwise dominated by female researchers.

Eight MSc degrees have been completed within the project.

Asian Institute of Technology (AIT), Rangsit, Thailand

AIT is presented in more detail in the main report, section 3.1.

Team Leader and Principal Investigator: Professor Ajit P. Annachhatre, also ARRPET Coordinator

A total of 24 researchers have been engaged since 2004, consisting of 12 female and 12 male researchers:

Name	Position	Status	Country
1. Mr. Warounsak Liamlean	Ph.D student	completed	Thailand
2. Mr. Apipong Lamsam	MSc student	completed	Thailand
3. Mr. Nguyen An Khang	MSc Student	completed	Vietnam
4. Mr. Jenyuk Lohwatcharin	MSc Student	completed	Thailand
5. Mrs. Salata Pradhan	MSc Student	completed	Nepal
6. Ms. Wilawan Khanitchaidecha	MSc Student	completed	Thailand
7. Ms. Phyu Phyu Htwe	MSc Student	completed	Myanmar

Name	Position	Status	Country
8. Mr. Zaw Ko Oo	MSc Student	completed	Myanmar
9. Mr. Phan Thong Thai	MSc Student	completed	Vietnam
10. Mrs. Shanta Chakrovortty	Research Associate	assignment completed	Bangladesh
11. Mrs. Salata Pradhan	Research Associate	assignment completed	Nepal
12. Ms. Prairadda Cheypratub	Research Associate	assignment completed	Thailand
13. Ms. Evelyn Martel	Research Assistant	assignment completed	Philippines
14. Mrs. Anjali Sharma	Research Associate	assignment completed	India
15. Ms. Chanya Pokasoowan	Ph.D student	On-going	Thailand
16. Mr. Paphungkorn Teekayuttasakul	Ph.D student	On-going	Thailand
17. Mr. Terrawuth S.	MSc Student	On-going	Thailand
18. Mr.Chaloemchai N.	MSc Student	On-going	Thailand
19. Ms.Tran Thi Thanh Thuy	MSc Student	On-going	Vietnam
20. Mr. Myo Kyaw	MSc Student	On-going	Myanmar
21. Ms. Raquel P. Pedrajas	Senior Res. Assoc.	On-going	Philippines
22. Mr. Aung Zaw Naing Lin	Research Associate	On-going	Myanmar
23. Mr. Bal Krishna	Research Associate	On-going	Nepal
24. Ms. Maricel F. Bermejo	Program Associate	On-going	Philippines

Centre for Pulp and Paper (CPP), Bandung, Indonesia

This is a government research institute under the Department of Industry and Trade with the task of assisting the pulp and paper industry in Indonesia. It has a staff of 160 and its activities covers among other things development of environment friendly technologies, paper making technologies, wastewater treatment, analyses and testing services for the industry, etc.

Team Leader: Ms. Wieke Pratiwi

De la Salle University (DLSU), Manila, Philippines

This is a catholic university and affiliated with the worldwide network of Lasallian communities. Recognizing that research is the key to a more profound understanding of theories and principles learned in the classroom, the university invests heavily into research. Research outputs are expected to improve people's lives.

Team Leader: Professor Susan M. Gallardo

University of Moratuwa (UoM), Sri Lanka

This university with about 3,000 students is regarded as one of the best technical universities in Sri Lanka.

Team Leader: Dr. M.W. Jayaweera

The research team consists of 12 male (4 researchers, 5 students and 3 research assistants) and 13 female (2 researchers, 5 students and 6 research assistants) members, indication a quite even gender balance – although with a male bias towards researcher and leadership and a female bias towards technical staff.

Students engaged in the research:

Name of Researcher	Topic/Thesis	Progress
Mr. Ayantha Gomes (Full Time)	Removal of iron and manganese from textile wastewaters using anaerobic attached growth bioreactors	Msc Completed
Mr. C.L. Lowe (Part Time)	Performance of a subsurface flow (ssf) wetland comprising phargmites karka in the removal of a zn containing metal finishing effluent	Msc Completed
Mr. Shiran Randeniya (Full Time)	Removal of zn from metal finishing wastewaters in subsurface flow (ssf) wetlands comprising typha angustifolia and scirpus acutus	Msc Completed
Mr. C.D. Ratnasinghe (Full Time)	Investigation into the unaccounted mechanisms (including microbial mechanisms) of metal removal in ssf wetlands comprising emergent aquatic plants with special emphasis on immobilization in sediments and detritus	Registered/Research Work On-Going
Ms. N.N. Satanarachchi (Full Time)	Improving the efficiency of ssf constructed wetlands comprising phargmites karka, typha angustifolia and scirpus acutus with special emphasis on immobilization in the calicut tile media	Registered/Research Work On-Going

Universiti Kebangsaan Malaysia (UKM) or National University of Malaysia, Selangor, Malaysia

This is one of the oldest universities of Malaysia and one of the three designated as a research university. It has a student population of about 30,000 students. The ARRPET project is handled by the Department of Engineering

Team Leader: Professor Abu Bakar Mohamad. There are currently 4 males and 5 female research personnel in the project, making up about 44% males and 56% females:

- Prof. Dr. Abu Bakar Mohamad (Leader)
- Prof. Dr. Rakmi Abd. Rahman
- Prof. Dr. Abdul Amir Hassan Khadum
- Assoc. Prof Dr. Siti Rozaimah Sheikh Abdullah
- Assoc. Prof. Dr. Mohd Sobri Takriff
- Dr. Nurina Anuar
- Azizah Haji Abu Bakar
- Zakiah Wan Sudin
- Mohd Hafizuddin Muhamad

Totally, fourteen researchers/students have been engaged:

Name	Institution	Length of training
1. Khor Mey Chea	UKM	PhD: 4 years-completed
2. Chia Sheau Khong	UKM	Masters: 2 years-completed
3. vAzizah Abu Bakar	UKM	Masters: 2 years (waiting for viva)
4. Chen Gang	UKM	Masters: 1 year-completed
5. Safura Shaari	UKM	Research Assistant: 2 years
6. Zakiah Wan Sudin	UKM	Research Assistant: 2 months
7. Mohd Hafizuddin Muhammad	UKM	Research Assistant: 1 month
8. Zanariah Jaini	UKM	BSc; 1 year-completed
9. Wong Fook Siang	UKM	BSc; 1 year-completed
10. Amy Charlene Wong	UKM	BSc; 1 year-completed
11. Liew Yi Huey	UKM	BSc; 1 year-completed

12. Tan Yen Chen	UKM	BSc; 1 year -progressing
13. Lee Wong	UKM	BSc; 1 year - progressing
14. Chia Wee Loon	UKM	BSc; 1 year - progressing

Subprojects

I. Removal of heavy metals from industrial discharges

Sulphidogenic processs for removal of heavy metals (AIT). This research originally concerned removal of of heavy metals from acid mine drainage. When an opportunity arose to use the same technology to solve an environmental problem in partnership with a commercial company (Thai Rayon) focus changed, and all efforts were concentrated on their waste water, heavily contaminated with zinc and sulphate.

Removal of heavy metals through bioremediation (CPP, DLSU, UKM, UoM) Heavy metal contamination is a problem associated with sevral types of industries and chemical methods are not suitable where concentrations of pollutants are low, e g contaminated soils. Microbial methods have been tested to remove low concentrations of pollutants in waste water and soil and phytoremidiation of waste water through constructed wetlands. The engineered constructed wetlands is a very promising technology that now is beeing introduced in Europe to immobilize and remove heavy metals from dump site leachate.

II. Removal of chlorinated organic compounds from industrial discharges (DLSU, ARI, UKM, CPP)

Pulp and Paper industry is a major industry in many Asian countries. It contributes significantly to the environmental pollution due to toxic waste as well as large volumes. At the same time it contributes to the economy of the country by generating resources, revenue and employment. Hence, to keep this industry going one needs to treat the effluent. However, there is no technology available that can effectively and economically remove AOX (the main toxic constituent of the effluent) from the industrial waste. AOX are chlorinated organic compounds commonly dominated by chlorophenols, but which may include dioxins, furans and other persistent organic pollutants, collectively referred to as Adsorbable (on activated charcoal) Organic Halides. AOX is a surrogate measure of the amount of chlorinated organic compounds in pulp and paper discharge. May importing countries have strict guidelines on maximum levels of AOX allowed on imported pulp and paper. Within EU most mills have converted to bleaching processes that do not produce AOX.

AOX is generated in the pulp and paper industry during chlorine based bleaching processes AOX compounds are formed as a result of reaction between residual lignin from wood fibres and chlorine/chlorine compounds used for bleaching. Many of these compounds are recalcitrant and have long half-life periods. Some of them show a tendency to bioaccumulate while some are proven carcinogens and mutagens. Hence, it is necessary to remove or degrade these compounds from wastewater.

Physical, chemical and electrochemical methods reported to remove AOX compounds are not economically viable. Different types of aerobic, anaerobic and combined biological treatment processes have been developed for treatment of pulp and paper industry wastewater. Maximum dechlorination is found to occur under anaerobic conditions. However, as these processes are designed specifically for reducing COD and BOD of wastewater, they do not ensure complete removal of AOX. Research on microbial methods for removal of AOX is carried out at CPP and at UKM, with focus on chlorophenols.

Polychlorinated biphenyls (PCBs) are a class of toxic compounds that were included in the list of banned chemicals (persistent organic compounds, or POP) due to its toxicity and persistence. There are, however, large remaining stockpiles, sites with contaminated soil and many old transformers and capacitors where PCB is mixed with mineral oil. Disposal is very problematic and expensive. There are specialized incinerating plants in Europe and the US that accept PCB for destruction, but due to the cost factor developing countries can not afford this. In the Philippines incineration of waste is also banned.

This leaves only microbial degradation as an option. There are several problems that have to be overcome, PCB is toxic to microbes and the oil is dark, and UV light that is needed for the process can not penetrate more that a few mm. Research at DSLU has addressed these problems and several interesting results have been obtained, with a pilot plant in operation.

Scientific Results

ARI. Literature was extensively reviewed at the beginning of the project and updated periodically. A literature review, "Anaerobic degradation of adsorbable organic halides (AOX) from pulp and paper industry wastewater" was published in 2006 in Bioresource Technology.

The studies were directed towards isolation of organisms with potential to degrade AOX more efficiently and more economically, with the aim to develop an upflow anaerobic filter (anaerobic fixed film reactor). The anaerobic techniques described in the "Microbiological Aspects of Anaerobic Digestion-Laboratory Manual" published by the laboratory were used. Reactor designing was carried out for maximizing the process efficiency and economic feasibility. In parallel, studies of aerobic degradation processes are carried out.

The results generated are of two kinds. Some of the microbiological research results are significant from a fundamental science point of view. There are few reports on the degradation of complex organochlorines (AOX) by anaerobic bacteria is rarely reported. One anaerobic isolate proved to be novel species of Clostridium. Technical results from the bioreactor-based treatment process developed in the form of upflow anaerobic filter showed degradation of over 83% of initial AOX. The possible practical implementation is still unclear, however, mainly because of that the high formation rate of pulp and paper industrial waste water in relation to the technical capacity of a microbial reactor, being more effective at a longer retention time of the water under treatment

The goals set up in the Logical Framework Approach Matrix in the beginning of the project have essentially been met.

AIT. The initial literature review resulted in an internationally published review paper on biological sulphate reduction.

AIT's research in particular dealt with development of biological processes for treating industrial effluents containing heavy metals and sulphate. The research was based on the hypothesis that a biological sulphate reduction process can convert sulphate into sulphide. The sulphide generated could be used for zinc sulphide precipitation which is much more stable than zinc hydroxide.

The objectives of the project have been met. The process that has been developed and now is tested in a pilot plant financed by Thai Rayon involves immobilization of zinc through precipitation as zinc sulphide by use of a microbial reactor. The technology appears to work very well with high removal rate, and the company contemplates to build a full-scale plant. The company has several factories around the world where this technology might be used. An added advantage is that part of the sulphur can be recovered and reused by the factory.

CPP. An initial literature review was conducted. The over all research objectives were to study the conditions for "Removal of Adsorbable Organic Halides (AOX) discharges from Pulp and Paper Industries" using Up-flow Anaerobic Sludge Blanket and Suspended Carrier Biofilm reactor technology.

The studies have been successfully pursued. The operation of pilot scale reactors are studied in collaboration with the PT. Kertas Padalarang pulp and paper mill, and other pilot experiments are planned at other industries. Several contacts at the Ministry level have resulted in cooperation with regard to establish an Indonesian effluent standard for AOX.

The objectives have generally been met, although the possibility for full-scale implementation suffers from the same problem as bioreactor technique in general, the large amount of effluents to be treated in relation to the need for sufficient retention time in the reactor for degradation to take place efficiently.

DLSU. An initial literature review was conducted, as well as interviews with concerned government authority officials and potential industrial partners.

The research has focused on photolytic and microbial biofilm oxidation processes in the degradation of PCBs, aiming on the treatment of PCB-rich hazardous waste stockpiles.

Research at DSLU has solved most of the problems associated with the development of such techniques, and a pilot plant has been built in cooperation with an industrial company, Planters Agri-Chemical Corporation Ltd. If the process can successfully be optimized it might become a very competitive technology compared to incineration, also of other POP such as chlordane, etc. As an indication of international interest in this field can be mentioned that an article by the group became the number one best selling article at Amazon in March 2007. Another article was listed on the top 25 Hottest Articles list (by Science Direct) and two other articles have been awarded the 2007 Outstanding Scientific Paper by National Academy of Science and Technology (Philippines).

UoM. Literature reviews have been conducted, with different approaches depending on the phase of the project, and relevant research papers gathered and categorized.

The hypothesis guiding the work has been that constructed wetlands with subsurface system under stress conditions (heavy metal stress) are well suited for the removal of heavy metals from industrial wastewaters. Constructed wetlands using three species of macrophytes have been studied, primarily with regard to their efficiency to remove zinc and lead. Also the recovery of metals retained by these systems has been addressed.

The results, as assessed in relation to the LFA matrix, have been well achieved. A pilot plant is in operation at a galvanizing industry, to remove zinc from the waste water. A large spin-off project is successfully addressing the remediation of a heavily polluted, ecologically sensitive wetland adjacent to a major dumpsite, turning it into a touristic resort and a "bird paradise".

UKM. Literature has been reviewed on the area of study, which is removal of AOX in waste water from pulp and paper mills in Malaysia, and study of metabolites formed. The initial literature review was published as a joint publication with the ARI and

The research objectives were met by studying AOX degradation and removal by a Granular Activated Carbon – Sequencing Batch Biofilm reactor. This combined process gives a more effective AOX removal than traditional activated sludge treatment. A pilot plant is in the early stage of development. The AOX components addressed are limited to chlorophenolic compounds as determined by HPLC technique. The validity of the method remains to be confirmed by comparing with results from standard AOX determination.

The work conducted generally meets the expectations in the LFA matrix

General about scientific quality: The use of statistics in results evaluation has varied considerably between the NRI. Some are systematically using relevant statistical replication and evaluation, while it is a bit neglected in some groups. Analytical quality may also be a matter of concern. This was not deeply looked into, but apparently a basic approach such as confirmation by "spiking" was novel to some researchers involved in analytical chemical work. In general, the microbial work appears to be of high quality, while the analytical chemical elements may be more variable – and systematic Quality Assurance not always in place. Notably, the LFA matrix has commonly been used for internal follow-up (NRI level) of achievements.

Networking

Internal networking works well at the laboratories visited. Communication is free and informal. Networking with the other NRI in the Subject Matter Area used email, telephone, training workshops, and regional and annual meetings. In particular the Environment Impact Assessment and Cost-Benefit Analyses required networking, as the expertise on this matter is to be found at the NRI at University of Moratuwa, Sri Lanka. Networking between NRI working on related research issues has been intense. Networking outside ARRPET has also been taking place, e.g. ARI with IIT in Bombay.

Dissemination

Results were communicated at multiple levels. Almost 20 papers were published in international, peer-reviewed journals (http://www.arrpet.ait.ac.th/hwtm/Hazardous-website/Hazardous-Publications.htm; not fully updated), additional publications were made in regional scientific journals, and several conference and newsletter contributions were made. Joint publications between the NRI active in the same or related research areas were made. Several seminars and workshops were held, with participation both from other NRI and from researchers outside the ARRPET program (Table 1). Industry has been kept informed about results, in particular where pilot scale studies are implemented or planned. Many researchers disseminate knowledge acquired in the ARRPET project by frequent lecturing at other universities and institutes in their own or other countries in the region, and also radio communication has been made.. Some NRI have contact with national authorities and exert some influence on policies and limit values, and raising the issue of the need for e.g. AOX discharge standards, which are not in place in most Asian countries. The TL of the NRI at UoM in Sri Lanka chaired the Central Environmental Authority committee on revision of environmental limit values.

Table 1. Seminars and workshops held by IHWTM NRI

2003
ARRPET National Workshop II on Removal of Recalcitrant Organics and Heavy Metals. 29th May 2003. Kuala Lumpur, Malaysia.
2005
Phase II: Training workshop on Molecular Techniques, AIT, Thailand, 21–25 March 2005
Training on UASB and Anammox Process, AIT, Thailand, 21–25 March 2005.
2006
Combined Regional Workshop of Hazardous Waste Treatment and Management (HWTM) and Wastewater Treatment and Management (WWTM), June 5–6, 2006, Center for Pulp and Paper (CPP), Bandung, Indonesia.
Training Programme on Health and Environmental Toxicity Assesment. Agharkar Research Institute, Pune India (11–13 Sept 2006).
Training programme on GC-MS (September 15–16, 2006) at Agharkar Research Institute (ARI) Pune-India:
2007
Combined Regional Workshop of IHWTM and WWTM, 4–6 July, 2007, The Dukes Retreat, Khandala, Maharashtra, India, Organized by ARI, India
Technical Training on Instrumentations and Toxicity Analysis for Persistent Organic Pollutants (POPs), DLSU, Philippine (25–27 Jan 2007) (Dr Nurina Anuar).
ARRPET II – Center for Pulp and Paper 2nd National Workshop 2007, Bandung, Indonesia, August 22, 2007

Capacity Strengthening

Capacity strengthening has mainly been through MSc education, although some of the NRI have also engaged PhD students. Research capacity has also been strengthened by the activities themselves. In addition, at ARI the Institute provided funds for several pieces of heavy equipment to make participation in ARRPET possible. ARRPET funds could not be used for this purpose, so the institute procured Gas chromatographic equipment, HPLC, AOX analyzer, and Fluorescent-Phase contrast microscope with camera attachment. Also at UKM, the Faculty has provided an instrument (GC-ECD) needed for the research initiated through ARRPET.

Compilation of Questionnaire

Method of interpretation

The replies by each NRI have been compiled below in the form of a scoring system; 1–5 representing as below:

1) not achieved
2) almost achieved
3) achieved
4) excellent
5) very excellent

The scoring builds on compilation of the results from each NRI, meetings with the team leaders and many of the students. Such a scoring method is used to try to facilitate the understanding for the reader but will be subjected to the evaluator ability to interpret correctly the replies.

The scoring represents and average of all NRI. If the variation is large a range of scores is given.

Questions	Score	Comment
Quality and relevance to the Asian region of research within the ARRPET frame, with focus on hard science and technology		
Scientific methodology		
Literature review, knowledge of the status of science. Where initial literature reviews done and the knowledge implemented into the project?	3–5	
Formulation of objectives. Where objectives spelled out at the NRI level? Did the NRI contribute to theme objectives?	3–4	
Formulation of hypothesis. Where research based on hypotheses?	2–3	
Research plan – Experimental design, field design of trials relevance of location and methods for data collection	2–3	
Evaluation of data, statistical data analysis when appropriate	1–3	
Scientific results		
Has high quality scientific results been generated?	2–5	
Has scientific results been generated which are relevant to the Asian region and which has focused on hard science and technology?	4	
Has the scientific results generated been relevant for, and have had an impact on, national and regional initiatives for policy plans controlling urban and environmental pollution?	1–3	
Feasibility and relevance		
Researchers' training and research experience related to the projects	3–5	
Rationale for the research; analysis of problems; and identified beneficiaries	3–5	
Feasibility of the project in relation to time and resources	2–4	
Consideration of environmental and safety aspects	2–5	
Likelihood of results to be applied	2–5	
Relevance of results to scientific advancement	1–4	
Relevance of results to national priorities	1–5	
Relevance of results to socio-economic conditions	2–3	
Mobilisation and strengthening of competence and capacity in the National Research Institutions (NRI) participating in the ARRPET Programme, in conducting research relevant for controlling urban and environmental pollution, and in relation to national and regional initiatives and policy plans		
Gender balance and equity		

Questions	Score	Comment
Percentage of researchers of each sex, and total number of researchers participating at each NRI	2–4	Within 40:60 at 4/6 NRI but less F leadership
Did the scientific results take into consideration gender and equity, when appropriate?	1–3	
Scientific capacity strengthening		
Composition of NRI research team, and changes over the years considered, with regard to academic degrees	3–4	
Has a critical mass of researchers been established at NRI	2–4	
Are researchers outside ARRPET contributing to critical mass at NRI	3–4	
To what degree have the NRI activities contributed to capacity strengthening at regional level?	2–4	
Has NRI team members left to be employed/take up studies elsewhere	3	
Has the leaving of researchers affected regional research capacity	2–5	
Networking		
Communication between researchers at each NRI	4–5	
Communication between NRI	3–5	
Continuous overview of the NRI activities by AIT (addressed to ARRPET Coordinator)	5	
Overcoming varying scientific infrastructure and scientific tradition at NRI	3–4	
Experts from Sweden; input, influence, impact	2–3	
Researchers links with policy makers; contacts, influence, impact	1–5	
Overcoming varying level of cooperation among governments in providing data to the researchers. To what extent has this been a problem?	1–3	
Create links between national institutions and regional initiatives to strengthen environmental remediation and protection in urban areas	3–5	
Networking outside ARRPET to the benefit of ARRPET theme activities	4	
Support from AIT to research institutions		
Has AIT supported in general management at Theme and NRI level?	5	
Has AIT supported in Theme and NRI administration?	5	
Has AIT supported in coordination at Theme and NRI level?	5	
Has AIT supported Theme and NRI scientific supervision?	4	
Has AIT supported in project management at Theme and NRI level for the Running projects in actual practice?	4	
Has AIT supported in the functioning of the Steering Group?	4	
Importance of Annual Review Meetings to Themes and NRI?	4	
Spin-off projects: the importance of these?	1–5	
Achievement of goals		
At the beginning of the project a Logical Framework Approach (LFA) matrix was made for each subject matter area as well as for the program as a whole. The LFA lists objectives, expected results, activities, assumptions and indicators.		
Where the objectives met?	3	
Which outputs were generated? Output is defined as: the products, capital goods and services which result from a development intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes [17]	2–3	
Which outcomes were achieved? Outcome is defined as "the likely or achieved short-term and medium-term effects of an intervention's outputs" [17]	1–3	
Achievements in relation to the logical framework approaches developed July 2000 at AIT meeting		
Develop technical solutions adapted to local conditions	2–4	

Questions	Score	Comment
Formulate policy recommendations for these solutions	1–4	
Strengthen existing research capacity in the region	3–4	
Disseminate the research results, academic as well as technical	3	
How has the collaboration with EEPSEA which performs environment-financial analyses been?	1	
What was achieved in relation to Environmental Impact Assessment that was presented in AIT project proposal?	5	
Dissemination of results of the programme among policy makers and the possible impact on environmental policy (locally, regionally and nationally)		
Dissemination of results		
Local peer reviewed journals	1–5	
Global peer reviewed journals	2–4	
Reports addressing technicians and end-users in actual practice	1–2	
Reports addressing policy makers, easy-read synthesis report in order to influence policy making	1–4	
Reports addressing product developers	1–3	
Seminars	2–4	
Implementation of results		
Where technical solutions to environmental problems suitable for local conditions developed?	1–4	
Where policy recommendations based on such technical solutions to environmental problems suitable for local conditions provided?	1–3	
Where science, technology, financial aspects and policy integrated?	1–2	
Did the project contribute to strategically environmental friendly production	1–3	
Finance		
Did NRI have an influence on fund allocation between NRI?	Y/N	(AIT)/(Other NRI)
Has funds been distributed in a way that has not hindered the activities at NRI?	Yes	
What is the proportion of ARRPET financing in relation to the overall financing of your research in the specific areas?	50–80%	Most other financing "in kind"
Would certain research project not have been realized without ARRPET financing?	Yes	
What will happen to your research in certain areas if ARRPET financing will not be provided for the discussed Phase III?		will not result in policy influence/ significantly hindered
Would you rather like to use potential funding for the discussed Phase III in some other way than just for a continued/enhanced research work in specific areas?		Pilot trials, scholarships, equipment, coop. w. Swedish labs
What are the co-funding options for the future?		Industry, other Sida funds, other natl or internatl funding

[17] Molund, S and Schill, G (2007). Looking Back, Moving Forward. Sida Evaluation Manual, 2nd revised edition, Sida, Department for Evaluation and Internal Audit, Stockholm, Sweden.

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