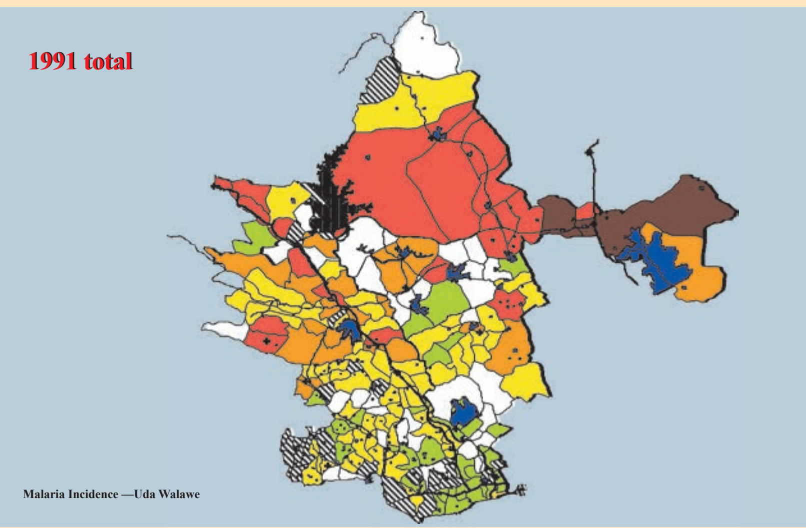
WORKING PAPER 29

# Malaria Risk Mapping in Sri Lanka—Implications for its Use in Control

## Proceedings of a Workshop held in Colombo 25 May 2001




Eveline Klinkenberg, editor

IWMI
International Water Management Institute

FUTURE HARVEST
IWMI is a Future Harvest Center supported by the CGIAR

Working Paper 29

# Malaria Risk Mapping in Sri Lanka—Implications for its Use in Control

**Proceedings of a Workshop held at the**
**International Water Management Institute, Colombo**
**25 May 2001**

*Eveline Klinkenberg, editor*

**International Water Management Institute**

IWMI receives its principal funding from 58 governments, private foundations, and international and regional organizations known as the Consultative Group on International Agricultural Research (CGIAR). Support is also given by the Governments of Pakistan, South Africa and Sri Lanka.

The work in Uda Walawe was carried out with the aid of a grant from the International Development Research Centre, Ottawa, Canada.

IWMI gratefully acknowledges the support for its work on vector control from the government of Japan.

*The author:* E. Klinkenberg is Consultant, Malaria (Water, Health and Environment theme) attached to the International Water Management Institute.

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*/ water management / waterborne diseases / malaria / vectors / maps / GIS / remote sensing / risks / soil moisture / Sri Lanka /*

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Please direct inquiries and comments to: *iwmi-research-news@cgiar.org*

*Cover: Malaria incidence map for the Uda Walawe region.*

# Contents

# List of Abbreviations

| | | |
|---|---|---|
| AMC | = | Anti Malaria Campaign |
| API | = | Annual Parasite Index |
| DRPM | = | Deputy Resident Project Manager |
| DPDHS | = | Deputy Provincial Director of Health Services |
| DS | = | Divisional Secretary Division |
| EIR | = | Entomological Inoculation Rate |
| GIS | = | Geographical Information System |
| GN | = | Grama Niladari area |
| IWMI | = | International Water Management Institute |
| MOH | = | Medical Officer of Health |
| MSF | = | Médecin sans Frontières |
| NAG | = | National Action Group |
| NGO | = | Non Governmental Organization |
| PDHS | = | Provincial Director of Health Services |
| PHI | = | Public Health Inspector |
| RBM | = | Roll Back Malaria (Initiative) |
| RMO | = | Regional Malaria Officer |
| RS | = | Remote Sensing |
| TSG | = | Technical Support Group |
| WHO | = | World Health Organization |

# INTRODUCTION

This working paper contains the proceedings of the workshop on "Malaria risk mapping in Sri Lanka—implications for its use in control" that was held on May 25, 2001 at IWMI Headquarters in Colombo, which was a follow up to the workshop conducted on March 29, 2001 in Embilipitiya (Klinkenberg 2001). The workshop in Embilipitiya was organized at the local level to discuss the results of the malaria risk mapping work carried out by IWMI in the Uda Walawe region of Sri Lanka. Participants at this workshop were local health staff involved in malaria control work in the area and officials from the Land Use Planning Offices and Divisional Secretariats.

This second workshop was organized at the national level to discuss the possible application of GIS and Remote Sensing tools in malaria control in Sri Lanka in a broader perspective with staff of the Anti Malaria Campaign (AMC), Ministry of Health, representative of Universities involved in malaria research in the island and representatives of the WHO- Roll Back Malaria Program and Médecins sans Frontières (MSF).

# WORKSHOP PROGRAM

| Time | Topic | Speaker |
|---|---|---|
| 9.00-9.15 | Welcome and workshop objectives | Ian Makin, IWMI |
| 9.15-9.30 | Malaria in Sri Lanka, situation analysis and future trends | Dr. W.P. Fernando, Director AMC |
| 9.30-9.45 | RBM program in Sri Lanka, milestones and progress so far | Dr. A.N.A. Abeyesundere WHO RBM consultant |
| 9.45-10.15 | Barriers to prompt and effective care for malaria in the uncleared area | Brigg Reilley epidemiologist MSF |
| | **TEA** | |
| 10.40-11.00 | Water management for malaria control, IWMI's malaria research in Sri Lanka | Dr. Wim van der Hoek, IWMI |
| 11.00-11.30 | Malaria vectors in Sri Lanka | Dr. Felix Amerasinghe, IWMI |
| 11.30-12.30 | Towards a risk map for Sri Lanka, results of the Uda Walawe Region | Eveline Klinkenberg, IWMI |
| 12.30-13.00 | Surveillance and its use in malaria control in Sri Lanka | Dr. A.R. Wickramasinghe, Senior Lecturer, SJU[1] |
| | **LUNCH** | |
| 14.00-15.00 | Use of GIS and RS tools for malaria research and control | Lal Mutuwatta and Dr. D.M. Gunawardena, IWMI |
| 15.00-16.00 | DISCUSSION on the role of risk mapping in malaria control | All participants |
| 16.00-17.30 | Informal discussion and drinks | All participants |

[1]SJU = Sri Jayawardenapura University.

## PRESENTATIONS

### IWMI's Research

*Ian Makin, Regional Director Asia, IWMI*

The International Water Management Institute (IWMI) is a scientific research organization dedicated to studying the issues of the sustainable and productive use of water resources, particularly as they relate to agriculture, water scarcity and food security in the developing world. It is the only organization of its kind whose priority is to provide the scientific facts necessary to help developing countries reduce poverty through more effective management of their water resources.

In the past five years, the Institute has carried out dozens of research projects in Asia, Africa, the Middle East and Latin America. The objectives of this work are to:

- Identify the larger issues related to water management and food security that need to be understood and addressed by governments and policymakers.

- Help developing countries build their research capacities to deal with water scarcity and related food security issues.

- Clarify the link between poverty and access to water and to help governments and the research community better understand the specific water-related problems of the poor people.

- Develop, test and promote management practices and tools that can be used by governments and institutions to manage water resources more effectively, and address water scarcity issues.

The outputs of IWMI's work are to provide a clearer view of the situation that poor regions face, and new knowledge and tools to help governments understand and implement the changes needed. IWMI's research provides:

- *Poor people* with practical solutions to problems—such as groundwater depletion, water-borne diseases, salinization of farmland and unequal access to irrigation water—that threaten their food security, health and livelihoods.

- *Local communities,* with techniques and technologies to use their water resources more productively.

- *Governments* with research-based recommendations and support to help them make more informed water and agricultural policy decisions.

- *National and international organizations* with the tools and training necessary to generate and apply new scientific knowledge.

IWMI

**International Water Management Institute**

Mission

*Improving water and land resources management for food,livelihoods and nature.*

Risk Mapping Workshop - 25 may, 2001

IWMI

**IWMI's research activity addresses:**

- Alleviating poverty
- Increasing Productivity of water in agriculture
- Understanding Cross-sectoral water use issues

Risk Mapping Workshop - 25 may, 2001

IWMI

**IWMI research is characterized by:**

- Multidisciplinary approaches to water management research
- Long-term presence in developing countries
- Generation of International public goods
- A strong focus on knowledge transfer

Risk Mapping Workshop - 25 may, 2001

IWMI

**Outputs and impacts**

- Better scientific understanding of issues on improved water resource management
- Science-based solutions for improved productivity, sustainability, and equity in water use
- Enhanced capacity for conducting research and managing water resources
- Transfer of know-how through collaborative research with developing country partners

Risk Mapping Workshop - 25 may, 2001

IWMI

**Research Themes**

- Integrated Water Management for Agriculture
- Sustainable Small holder Land and Water Management Systems
- Sustainable Groundwater Management
- Water Resource Institutions and Policies
- Water, Health and Environment

Risk Mapping Workshop - 25 may, 2001

IWMI

**Integrated Water Management for Agriculture**

- Develop and apply new research methodologies for assessing and improving irrigation water management performance in an integrated water resource management framework
- Identify key methodologies, processes and actions that will contribute to poverty reduction and food and environmental security.

Risk Mapping Workshop - 25 may, 2001

**IWMI**

## Sustainable Small holder Land and Water Management Systems

- To identify and promote the uptake of appropriate small holder water management systems in order to contribute to better rural livelihoods of poor men and women and increases in water productivity

Risk Mapping Workshop - 25 may, 2001

**IWMI**

## Sustainable Groundwater Management

- To develop and disseminate a more accurate and refined understanding of the socio-ecological value of groundwater.
- To identify and promote research on promising technologies and management approaches.
- To promote sustainability solutions amongst strategic players in national and regional groundwater systems

Risk Mapping Workshop - 25 may, 2001

**IWMI**

## Water Resource Institutions and Policies

- Understand, through systematic comparative research, institutional arrangements and policy frameworks appropriate ways to improve the productivity of water in ways that promote livelihoods of poor men and women.
- Identify, test and evaluate research-based guidelines for water policy reform, organizational options and roles, and support systems for local management of irrigation that lead to more effective management of water in river basins.

Risk Mapping Workshop - 25 may, 2001

**IWMI**

## Water, Health and Environment

**Health**

- Bridge the gap between the water and health sectors
- Raise awareness and work towards the incorporation of health safeguards in water resources management and planning in rural areas through a research documentation and pilot field studies

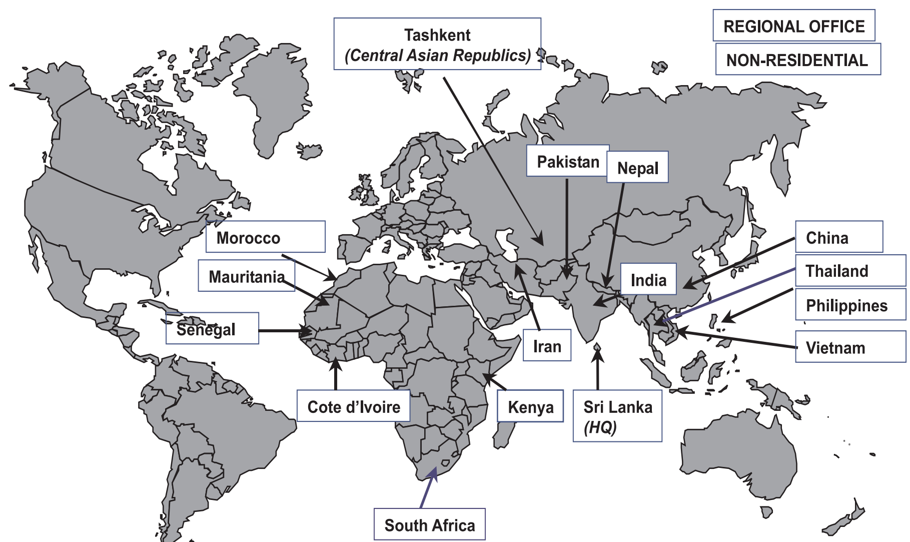
**Environment**

- Bridge the gap between irrigation and environment sectors
- Scientifically document the relationship between irrigation, water management and the environment in an integrated manner

Risk Mapping Workshop - 25 may, 2001

## Current Research Locations

**IWMI**




Risk Mapping Workshop - 25 may, 2001

## Malaria in Sri Lanka: Situational Analysis and Future Trends

*Dr. W. P. Fernando*
*Director, Anti Malaria Campaign, Sri Lan*ka

Malaria in Sri Lanka is characterized by high morbidity (210,039 confirmed cases in 2000), and relatively low mortality rates (76 reported deaths in 2000; e.g., 0.35 per 1000 patients). The most prevalent malaria species is *Plasmodium vivax* (70%), the rest of the cases are caused by *P. falciparum*. The principal vector is *Anopheles culicifacies* and the secondary vectors are *An. subpictus* and *An. annularis.*

Malaria is endemic in the 'dry zone' as the physical and climatic features are favorable for transmission in this area. In the intermediate zone epidemic type malaria predominates and the river system constitutes the main breeding habitat during dry weather when pooling occurs. In the wet zone malaria is focal and sporadic. Apart from this, several high-risk districts can be recognized These are the northern districts at the frontline of the ethnic conflict: Killinochi, Mullaitivu and Vavuniya. No data are available for Mannar but this district probably has a similar caseload to the other northern districts. The other high-risk area is the district of Moneragala in the southeast of the island.

There are several factors that have had an effect on the malaria transmission pattern during the last decade.

Unfavorable factors are:

- the conflict situation in the North-East Province
- emergence of malathion-resistance in the vector population
- spreading of chloroquine resistance in *P. falciparum* malaria
- increasing intra-country population migration

Favorable factors are:

- increased reliance on self protection methods
- efforts towards early detection and treatment of patients by Mobile Malaria Clinics
- action to forecast and prevent malaria outbreaks

Future needs in the malaria control program would be:

- to contain spreading chloroquine resistance in *P. falciparum*
- to prevent emergence of multi-drug resistant *P. falciparum* malaria
- a suitable drug policy specially for the treatment of *P. falciparum* malaria including drug resistant strains
- improved methods for forecasting of malaria outbreaks, including applications of GIS
- strategies for insecticide-resistance management in  vector populations
- more reliance on sustainable and eco-friendly biological methods of vector control
- application of principles of the Roll Back Malaria Initiative
- a better understanding of the sociological aspects of malaria control

**Malaria in Sri Lanka**

Situational analysis and future trends

Dr. Punsiri Fernando
Director,
Anti Malaria Campaign,
Sri Lanka

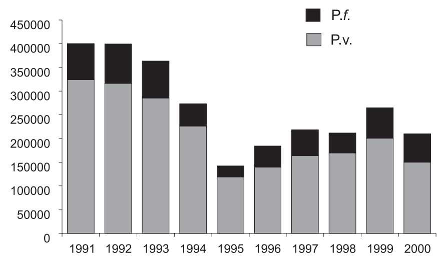
Morbidity - high (210039 confirmed patients in year 2000)

Mortality - very low (76 reported deaths in 2000
i.e. 0.36 / 1000 patients)

Prevalent species - *Plasmodium vivax* (72% in year 2000)
*Plasmodium falciparum (* 28% in year 2000)

Vector - Principal vector - *Anopheles culicifacies*
Secondary vectors - *Anopheles subpictus*
*Anopheles annularis*

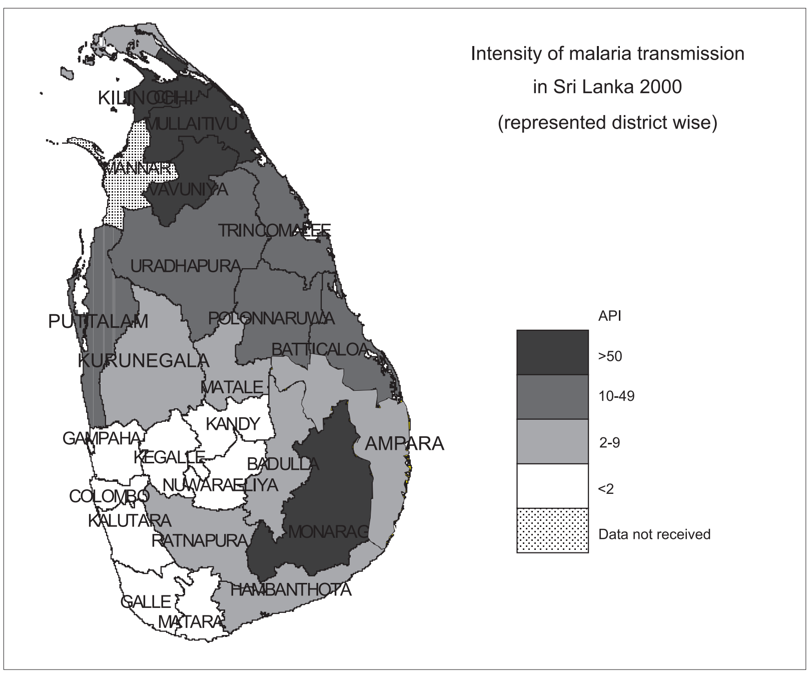
Malaria Trends in Sri Lanka
1991 - 2000




( No. of microscopically confirmed malaria
cases detected by the Anti Malaria Campaign )

Transmission Dynamics

- Malaria is endemic in the "dry zone" as the physical and climatic features of the "dry zone" of Sri Lanka are very favourable for malaria transmission.
- In the "intermediate zone" epidemic type malaria predominates. The river systems constitute the main breeding sites during dry weather.
- In the "wet zone" malaria is focal and sporadic.

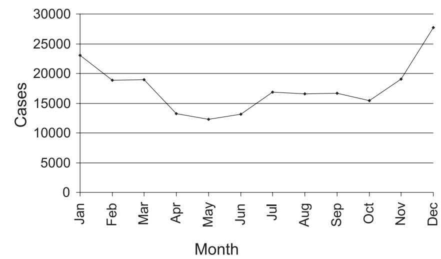


## Two transmission peaks are often seen

Major peak  December - January
follows North-East monsoon rain

Minor peak  June - July
follows South-West monsoon rain

Distribution of the malaria cases during the year 1998
showing the two transmission peaks.




## Some important factors which had effects on the malaria transmission pattern during last decade.

Unfavourable

- Conflict situation in the North-East Province
- Emergence of malathion-resistance in the vector population
- Spreading chloroquine-resistance in P.falciparum malaria
- Increasing intracountry population migration

## Favourable

- Increased reliance on self protection methods
- Efforts towards early detection and treatment of patients by Mobile Malaria Clinics
- Action to forecast and prevent malaria outbreaks

## Objectives of the Malaria Control Programme

Reduction of the countrywide malaria incidence at least by 50% during the next 5 year period

To minimize the proportion of P.falciparum infections.

To eliminate mortality due to malaria

To prevent malaria epidemics

To prevent malaria in pregnant mothers.

To protect children below 5 years from malaria.

## Malaria control measures

Parasite control - detection and treatment of cases
chemoprophylaxis

Vector control - adulticiding
larviciding - chemical - "Temephos"
biological - larvivorous fish
Bacillus thuringiensis
Pyriproxifen (growth)
hormone regulator)

Prevention of man-vector contact- bed nets (treated / untreated)
screening of houses
repellent smokes
repellents to be applied on body

Future needs

- To contain spreading chloroquine-resistance in *P.f.*
- To prevent emergence of multi-drug resistant *P.f.* Malaria
- Suitable drug policy specially for the treatment of *P.falciparam* malaria including drug resistant strains.
- Improved methods for forecasting of malaria outbreaks, including application of GIS

- Strategies for insecticide-resistance management in vector populations
- More reliance on sustainable and eco-friendly methods of vector control
- Application of principles of the Roll Back Malaria
- Better understanding of sociological aspects of malaria control

## RBM Program in Sri Lanka: Milestones and Progress So Far

*Dr. A.N.A. Abeyesundere*
*Consultant, Roll Back Malaria Initiative, World Health Organization*

Global perspectives

- More than a million people killed annually
- more than 300 million cases a year
- 1/5 of the world's population at risk

Reasons for the spread of malaria

- Weak health systems
- Large population movements
- Climatic changes
- Uncontrolled development activities
- Technical problems : drug resistance and insecticide resistance
- High cost of malaria control activities (partly due to drug resistance)

Roll Back Malaria concepts

- Evidence-based decisions
- Rapid diagnosis and treatment
- Multiple prevention
- Focused research to develop new tools
- Well coordinated action for stronger health systems
- Harmonized actions

### The Sri Lankan Roll Back Malaria initiative

Highest political commitment

**1998**
Hon. President of Sri Lanka, 1st Head of State formally agreed to Roll Back Malaria (RBM) Initiative

The former Minister of Health led the South Asian pledge to include Asia in RBM

**August 24th 1999**
RBM approved by Minister of Health
All Chief Ministers, Chief Secretaries have approved RBM

## Milestones

**October 1999**
A Malaria Research Committee was formed. Appropriate field research projects were developed. These include:

a. Studies on drug resistance—in vitro sensitivity to anti-malarial drugs

b. Combination drug therapy—Artesunate in combination with Sulphadoxine

c. Establishment of a computer-based surveillance system for malaria control activities

d. Study on the effect of insecticide impregnated curtains on the transmission of malaria in a malaria endemic area of Sri Lanka

e. Water management for malaria control in an area of the Huruluwewa watershed in Anuradhapura District

The total allocation from the World Bank funds amounts to Rs. 11,287,300

**October 1999**
5 Districts: Jaffna, Killinochi, Mullaitivu, Anuradhapura and Moneragala prioritized.

**October-December 1999**
Situation analysis and needs assessment guidelines developed.

**December 1999**
Situation analysis and needs assessment in the 5 districts completed by Provincial and District Authorities.

**January 2000**
National Action Group (NAG) formed. Situation analysis and needs assessment approved.Technical Support Group formed to assist the NAG.

**February 2000**

- Media seminar
- National workshop held

**April 2000**
Uva Province Meeting held, Presided by Chief Minister

**May 2000**
Combined North-Central Province (NCP) and Anuradhapura District Meeting, Chief Minister (NCP) presided

**July 2000**
Moneragala District Meeting, Chairman, Health Secretary Provincial Council—Uva presided

**August 2000**
North-East Province Meeting, Presided by the Provincial Director of Health Services (PDHS).

**August-September 2000**
Preparation of the Strategic Framework by the Technical Support Group (TSG) with the Provincial and District Authorities

**October-December 2000**
Development of the 5 year Strategic Plan

**January 8th 2001**
Five-Year Strategic Plan 2001-2005 approved by the National Action Group

**February -April 2001**
Preparation of detailed Plans of Action by District & Provincial Authorities

**26th -28th March 2001**
Media seminar at national level

**18th-20th April 2001**
Strengthening of District Health System to facilitate mainstreaming of RBM and development of Joint Action Plans in the Pilot Districts.

**April 2001**
Plans of Action finalized for the 5 Districts

**May 2001**
Plans of Action reviewed and approved by TSG

**June 2001**
NAG to approve Plans of Action
Planned activities to commence in the Districts (mid June)

## Barriers to Prompt and Effective Care for Malaria in the Uncleared Area

*Brigg Reilley*
*Epidemiologist, Médecins sans Frontières (MSF)*

The districts of Killinochi and Mullaitivu have some of the highest cases of malaria in Sri Lanka. Public health interventions are difficult due to the deterioration of the infrastructure caused by years of armed conflict.

Médecins sans Frontières (MSF) works in the government health facility in Mallavi, a Peripheral Unit in the Mullaitivu District. Health workers in Mallavi noted a high level of repeat treatment for malaria patients. To better understand the possible reasons for apparent treatment failure, MSF with the AMC desk in Mallavi investigated treatment seeking behavior (how quickly persons come to the Peripheral Unit for treatment) and treatment adherence (do patients take all their anti-malarial drugs). Persons were interviewed after malaria diagnosis and followed up after treatment. In addition, focus group discussions were held with teachers, mothers, and health care workers.

The study found notable levels of treatment delay. About half the patients came to the out patient department within two days of feeling ill. Delay was mostly because people elected to self-treatment, usually paracetamol. Other factors influencing delay included the long waiting time to get seen by a doctor. There were also levels of non-adherence to treatment. This was most often due to the side effects of chloroquine and/or if the malaria symptoms ended. In general it was found that there was a lack of confidence in chloroquine. The drug is believed to not always be effective, and is well known to have toxic side effects which makes it desirable to stop treatment as soon as the symptoms stop, rather than taking the full course of drugs.

The root causes for the apparent treatment failures rest largely with the negative impact of the conflict on the quality and access of care. There has been a huge influx of displaced persons, increasing the population of Mallavi by five times, and thereby increasing the demand on the health services. There is an acute shortage of staff, as most medical staff have fled the conflict, which causes long waiting times for the appointment of a medical consultation. Similarly, a lack of microscopists requires a greater dependence on clinical diagnosis of malaria. The long lines combined with the lack of staff encourage self-treatment and delayed seeking of treatment. Health interventions are difficult in this situation.

There are also significant barriers to prevention. The organization of a proper environmental campaign is problematic due to the lack of infrastructure, materials, staff, and erratic supply lines into the uncleared areas. Populations are semi-mobile, as areas are resettled once they are cleared of landmines. Using personal prevention means have an economic barrier, as bed nets are expensive for most persons. However, there are important non-economic barriers as well, such as bednets not being used because it becomes too hot to sleep under and bed net use is not perceived as significantly reducing one’s chances of contracting malaria. Any prevention campaign will need to not only help with supplies but also will need to convince people that prevention measures are effective and will have an impact.

Finally, lower treatment efficacy due to resistance to chloroquine is a possibility. Presently MSF and AMC are working on a small sample of a 28-day follow up of *P. vivax* and *P. falciparum* in an attempt to learn better patterns of resistance in the area.

*PowerPoint slides presentation*

**Medecins sans Frontiers (MSF)**

- Founded 1971 in Paris
- Independent and impartial
- Presently works in over 80 countries
- In 1999 awarded Nobel Peace Prize

**MSF in Sri Lanka**

- First started in Sri Lanka in 1986
- Dutch and French sections
- Work in government hospitals
- Surgical, obstetric, paediatric services
- Works in Vavuniya Batticaloa, Pt. Pedro, Jaffna
- Uncleared area: Madhu, Mallavi
  (Mallavi due to battle of Kilinochi 1996)

**Malaria in uncleared area:**
<3% of population has 36% of malaria

- Kilinochi and Mullaitivu districts 1999
- 36% total slide positive malaria in Sri Lanka
- 52% of total P. Falciparum malaria in Sri Lanka
- 63 of 102 (62%) of deaths

**Environmental interventions: difficult to maintain**

- Supplies irregular
- Lack of trained staff
- Fuel/transport/road difficulties

**Mallavi Peripheral Unit: outpatient department**

- Over 10,000 consultations in typical month
- 2 doctors
- 1 microscopist
- 5 days of treatment both types of malaria

**Prompt and Effective Care**
treatment seeking behaviour & treatment adherence

- Survey
- Pre and post treatment
- limits: underestimate adherence

- Focus groups
- mothers, teachers, health professionals
- limits: not statistical

## Treatment seeking behaviour
n = 271

| | |
|---|---|
| Treatment within 2 days | 54% |
| Treatment within 4 days | 84% |
| Prior to seeking treatment at OPD: | |
| Self-treatment | 92% |
| Friend/family | 12% |
| Pharmacy | 4% |
| - mainly paracetamol (96%), chloroquine (8%)<br>- obtained from shop (52%), home stock (36%) | |

## Treatment Delay

- Statistically associated with:
  self-treatment, consult prior to OPD
- long waiting time, work/house duties: more convenient to take PCT
- not found to be associated with age or distance
- perceived severity of malaria

## Treatment adherence
n=260

| | |
|---|---|
| Not take full tx: | 26% |
| Reasons: (multiple answers possible) | |
| Side effects of drugs: | 58% |
| Symptoms went away: | 17% |
| Food shortage: | 8% |
| Save for future illness: | 3% |
| Other: | 4% |

## Interventions

- Increasing staff not possible
- Awareness to promote full treatment
- Packaging/blister packs

## Resistance

- 18% in follow up still febrile on day 6
- Small resistance study underway with AMC
- *P vivax, P. Falciparum*

## Prevention
personal measures, bednets and coils

- Supplies irregular
- Economic barrier
- Skepticism of effectiveness

## Water Management for Malaria Control: IWMI's Malaria Research in Sri Lanka

*Dr. Wim van der Hoek, Theme leader*
*Water, Health and Environment, IWMI*

### Why water management?

Malaria control is facing major challenges worldwide due to several factors including increasing resistance of the malaria parasites against anti-malarial drugs and resistance of vector mosquitoes against insecticides. With no vaccine available, there is a need to find alternative methods of dealing with the disease. In the first part of the twentieth century, a lot of experience was gained with environmental management methods to control the mosquitoes that transmit malaria. However, this knowledge was done away with when DDT became available after World War II, leading to a global campaign to eradicate malaria by spraying houses with this insecticide. Currently, environmental management plays an insignificant role in malaria control programs but it should become more important in future control activities.

### Flushing of streams

Due to the breeding preference of *Anopheles culicifacies* for streams and rivers, water management has long been considered an effective intervention in Sri Lanka. Between 1934 and 1936, experiments were performed with engineering and manual measures to reduce the creation of pools in rivers (Worth 1937). Clearing the stream from falling trees, creating drainage canals along the side of the stream, filling up permanent rock pool formations and constructing special dikes made the stream less conducive for the breeding of the vector mosquitoes. Technical feasibility tests were carried out in a number of rivers and streams using hand operated flushing devices and automatic siphons to flush waterways. Much later flushing activities were carried out in the Mahaweli River below the reservoirs close to Kandy town aimed at reducing the mosquito breeding potential (Wijesundera 1988). However, due to the conflict with other water management objectives, e.g., hydropower generation, this practice was stopped.

Several other countries in Asia, including India, the Philippines, Indonesia, and Malaysia have made extensive use of automatic siphons. Siphons that were constructed in Penang, Malaysia before World War II are still in good operating condition (Jobin 1999).

### The case of the tank cascade systems in Sri Lanka

One of the salient features in the landscape of the Sri Lanka dry zone is the water reservoirs. There are an estimated 18,000 of these tanks in Sri Lanka and many are interlinked through canals or natural streams to form cascades. In 1994, IWMI initiated a study in the Huruluwewa watershed assessing the options for control of malaria vectors through different water management practices in a natural stream that formed part of such a tank cascade system. The studies established conclusively that *An. culicifacies* was the major vector of epidemiological importance and that a small river, the Yan Oya, was the primary vector-breeding habitat in the watershed, which posed a significant risk factor for malaria early during the transmission season. Villages further away from the stream had lower densities of the main vector, and concomitantly lower malaria than the villages closest to the stream. Detailed analyses of water dynamics of the entire watershed area have been used to model different water management practices that could reduce vector breeding in this key habitat and thereby have a system-wide impact on malaria in the watershed. The most viable management option was a redistribution of existing water flows in order to maintain a water depth sufficient to discourage the breeding of the vector (Matsuno et al. 1999). Costs analyses of the potential water management measures and other vector control interventions such as the spraying of houses with insecticides and the use of bed nets have shown that flushing the streams through seasonal water releases from upstream reservoirs would be the cheapest vector control measure (Konradsen et al. 1999). These studies were implemented by a multidisciplinary research team with expertise in the diverse disciplines of vector ecology, parasitology, epidemiology, social science, economics and irrigation engineering (representing IWMI, the University of Peradeniya and the Anti-Malaria Campaign). In the second phase of this project the water management methods will be implemented on a routine basis in consultation with the health workers, irrigation managers and farmers and the impact on vector mosquitoes and malaria incidence monitored.

Water management and other environmental management methods deserve a place in malaria control activities. Key issues in determining the success of environmental methods are (1) knowledge of the local vector ecology and malaria epidemiology; and (2) close interactions and real collaboration between health specialists and engineers.

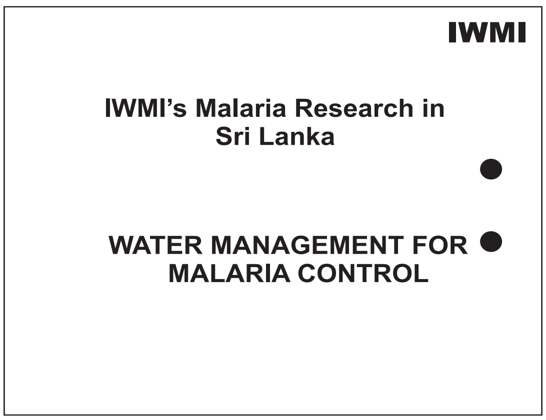
## Towards a risk map of malaria for Sri Lanka

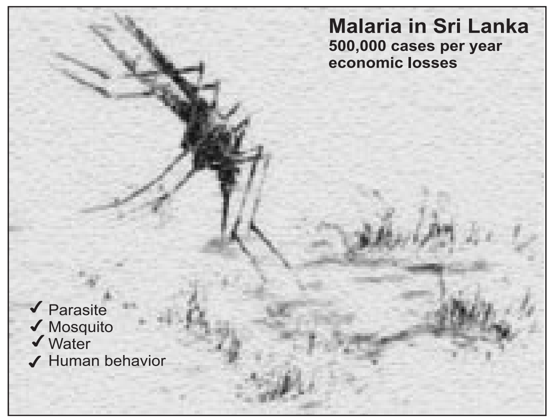
It is a logical step from detailed studies on vector ecology, risk factors for malaria, and socioeconomic aspects of the disease to the development of a risk map for malaria. Such a risk map would primarily be based on the availability of surface water that has the potential for pooling and generation of vector mosquitoes. It is expected that people living close to the breeding sites are at higher risk for malaria than people living further away. In a geographic information system (GIS), the malaria incidence and population distribution could be superimposed on a map of all potential breeding sites. This makes it possible to derive a function showing the relationship between distance to breeding site and malaria. In a GIS other variables that play a role in malaria transmission can also be included. Some information, such as land use patterns can now easily be obtained from satellite remote sensed imagery and imported into GIS.

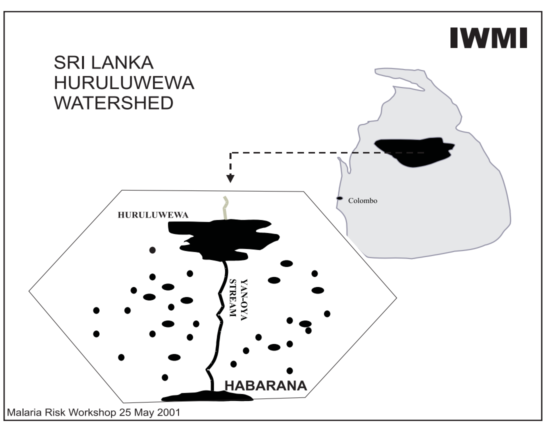
A malaria risk map will make it possible to target priority areas with control activities, such as insecticide house spraying, larviciding, and bed net programs. Including temporal changes in the malaria risk map will make it possible to use it as an early warning system for impending epidemics.

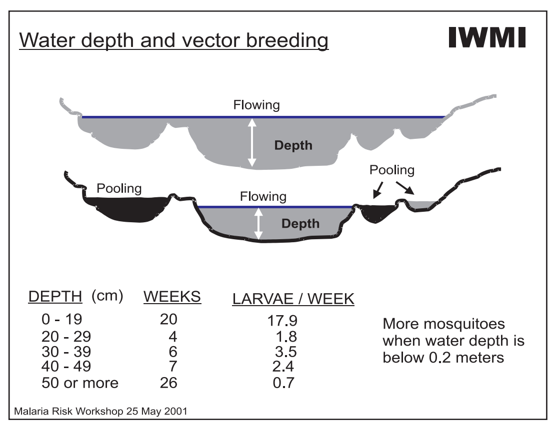
The first phase of the IWMI project was implemented in the Uda Walawe area where malaria incidence was mapped and related to environmental variables at the lowest administrative (GN) level. Larval, adult and human malaria surveys will be needed to validate predictive models. These models will then be modified if necessary. An extension of the risk map project is proposed in a more participatory way. Regional workshops would be held where staff from AMC and the Ministry of Health are encouraged to collect the necessary data from their own areas. Training will be provided to enable participants to process the data and make the resulting maps available for routine management. This exercise could then be expanded to other divisions and districts in a stepwise fashion and eventually cover the entire island. For this approach to be successful, a partnership is needed between the Ministry of Health (including AMC), research organizations (universities, IWMI), international organizations (WHO), and NGOs working in poorly accessible areas.

*PowerPoint slides presentation*



## Huruluwewa watershed

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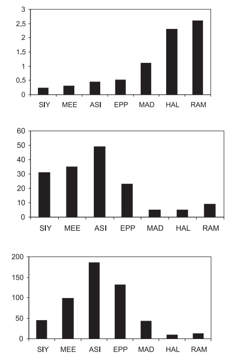
Average distance from Yan Oya (km)

Number of *An. culicifacies* per house (km)

Number of malaria cases per 1000

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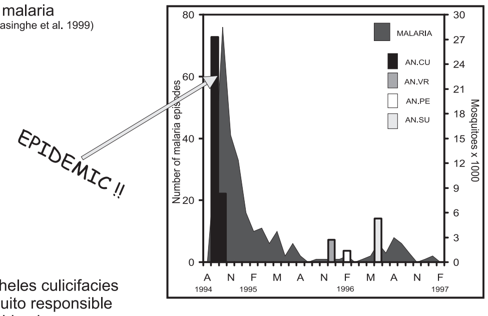
## Mahameegaswewa

**IWMI**

infective vectors and malaria

(Amerasinghe et al. 1999)




Anopheles culicifacies mosquito responsible for epidemic

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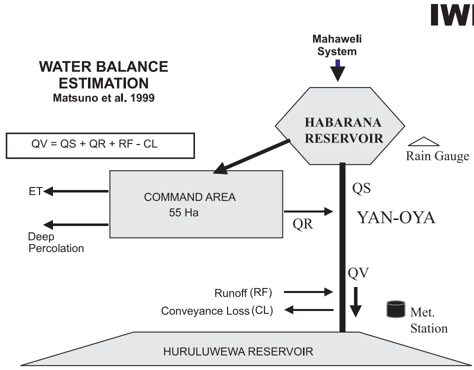


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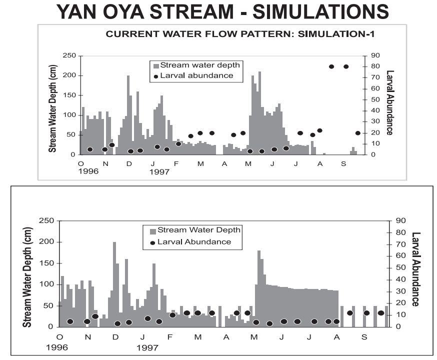
**IWMI**

## YAN OYA STREAM - SIMULATIONS

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## Cost of malaria control

| | US$ |
|---|---|
| Insecticide spraying | 2.75 |
| Impregnated bed nets | 1.02 |
| Larviciding | 0.53 |
| Water management | 0.26 |

Total annual cost per individual protected

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## Huruluwewa: 7 villages

n = 210 cases, 1100 controls

| Distance house - stream | Relative Risk for malaria |
|---|---|
| < 250 m | 13.6 |
| 250 – 499 | 6.8 |
| 500 – 749 | 9.2 |
| 750 – 999 | 1.3 |
| 1000 – 1249 | 1.7 |
| >= 1250 | 1.0 |

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## Clearing of dead trees blocking the stream

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## Straightening stream bed

- ✓ Excavate shallow inner bends
- ✓ Use government excavator and personnel
- ✓ Excavator crawls along stream straightening, pushing live trees, removing dead logs
- ✓ Removed ground to be deposited in sand mining pits

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## Laundry and bathing sites

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## Rapids (continued)

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CGIAR
sima
SYSTEMWIDE INITIATIVE ON MALARIA AND AGRICULTURE

IWMI

ACTION PLAN

for a

Systemwide Initiative
on
Malaria and Agriculture

PROPOSAL OUTLINE 1
May 16, 2001

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CGIAR
sima
SYSTEMWIDE INITIATIVE ON MALARIA AND AGRICULTURE

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*Better agro-ecosystem management can contribute to malaria control, leading to increased agricultural productivity and poverty alleviation*

- Scientific documentation of interactions between agriculture and malaria
- Agricultural practices, development strategies and policies tested and developed
- Partnerships between the health and agricultural sectors
- Capacity enhanced for inter-sectoral research on health and agriculture

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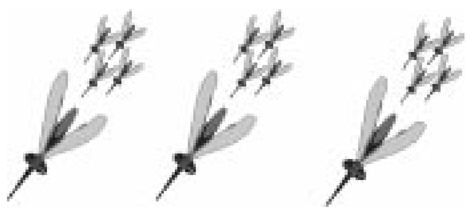
# Malaria Vectors in Sri Lanka

*Dr. Felix P. Amerasinghe, Principal Researcher,*
*Water, Health and Environment Theme, IWMI*

*Anopheles culicifacies* was originally incriminated (between 1913 and 1930) as the vector of malaria in Sri Lanka based on the evidence of dissections. More recent Enzyme Linked Immunosorbent Assay (ELISA)-based evidence (sometimes supplemented by dissection) has shown a large number of anopheline species to be infected in addition to *An. culicifacies*. These species are *An. aconitus, An. annularis, An. barbirostris, An. nigerrimus, An. pallidus, An. peditaeniatus, An. subpictus, An. tessellatus, An. vagus* and *An. varuna*. This does not automatically mean that all these species are effective field vectors. Species that have consistently been incriminated are *An. annularis, An. subpictus, An. vagus, An. varuna* and (to a lesser extent) *An. tessellatus*. These species have differing biting and resting behaviours that place humans at differential risk, depending on the vector. *An. culicifacies* and *An. subpictus* bite indoors and outdoors, but the other species are primarily outdoor biters. Biting periodicity too, varies from species to species. Malaria control entomology in Sri Lanka is based around *An. culicifacies*, and so the major strategy is of indoor residual insecticide spraying that targets indoor resting and feeding adults. Vector control of immature stages, too, is directed at the primary vector alone, in the form of larviciding the major breeding habitats such as stream and riverbed pools. There is presently no effective strategy against the subsidiary vectors—those that bite primarily outdoors and breed in a multitude of other habitats. Ecological research over the past two decades has resulted in good information on the ecology of these species that could be used to advantage in devising control options where such species are locally important in transmission. Another aspect that deserves more attention is that of sibling species: recent research shows that siblings B and E of *An. culicifacies* occur in the country, and based on Indian studies, the latter appears to be the efficient vector. We know little of the differential ecologies of these two siblings in Sri Lanka. Four siblings (A,B,C,D) of *An. subpictus* are present, with the salt-water breeding sibling-B prevalent in coastal areas, and the freshwater breeding sibling-C prevalent in inland areas. Whilst *An. subpictus* s.l. has been regularly incriminated in malaria transmission, we have little information on which sibling is involved—a very limited study has implicated sibling-C, but this study is certainly of inadequate size and duration for firm conclusions to be drawn. Two sibling species are presently known for *An. annularis*, but their status in Sri Lanka is unknown. Investigating this is a matter of some importance because *An. annularis*, too, is a species that has been involved in malaria transmission in several instances in the recent past. Research on these subsidiary vectors of malaria is very relevant because it is likely that they will assume greater importance in transmission as human populations increase and more and more natural resource areas are opened up for human settlement.

**IWMI**

## MALARIA VECTORS IN SRI LANKA



Felix P. Amerasinghe

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## Several anopheline mosquitoes implicated in malaria transmission in Sri Lanka

*Anopheles aconitus*
*Anopheles annularis*
*Anopheles barbirostris*
*Anopheles culicifacies*
*Anopheles pallidus*
*Anopheles peditaeniatus*
*Anopheles nigerrimus*
*Anopheles subpictus*
*Anopheles tessellatus*
*Anopheles vagus*
*Anopheles varuna*

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## Sri Lanka

All evidence points to major vector being *An. Culicifacies*

Evidence also indicates that *An. Subpictus* is a secondary vector.

Other species that could be locally important in transmission are: *An. Annularis, An. Tessellatus, An. Vagus and An. varuna.*

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## Documented instances of other vector involvement in malaria transmission

*Anopheles annularis* - Mahaweli System-C; System B; Southern Sri Lanka? (PF/PV)

*Anopheles subpictus* – *Kataragama Mahaweli System-C (PF/PV)*

*An. Varuna* - Elahera, Huruluwewa (PV-VK247*)*

Other instances in grey Literature?
E.g., Among recent AMC records*?*

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## BITING & RESTING HABITS

*An. Culicifacies, An. subpictus:*

Main control strategy: indoor residual spraying, bednets

Indoor & outdoors

No control strategy

*An. Annularis, An. tessellatus*

Primarily outdoors

*An. Vagus, An. Varuna:*

No control strategy

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## BREEDING - major habitats

*An. culicifacies*: stream/riverbed pools

Main control strategy: larviciding

No control strategy

*An. Subpictus, An. vagus*: turbid pools, rice fields
*An. Tessellatus*: rainwater pools
marshes, tank, canals
pools

*An. Annularis:*
*An. Varuna: streams,*

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## Sibling species:

Morphologically identical (or almost identical) in all life stages (larva, pupa, adult).

Genetically distinct, reproductively isolated.

Behaviourally distinct: breeding/biting/resting

Different vectorial capacities

Different insecticide resistance capabilities

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## Sibling species can be detected on the basis of:

- Inversions on polytene chromosomes
- Structural variations in metaphase Y-chromosomes
- Electrophoretic variations in LDH-enzymes
- Species-specific cuticular hydrocarbon profiles
- DNA-probes
- Polymerase Chain Reaction (PCR) assays

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## Anopheles culicifacies consists of a complex of 5 sibling species (A, B, C, D, E,)

INDIA

| | A | B | C | D | E |
|---|---|---|---|---|---|
| % Human biting | 0-4 | 0-1 | 0-3 | 0-1 | ? |
| Biting Activity | All Night | All Night | All Night | Upto Midnight | ? |
| Peak biting | 22-23 | 22-23 | 18-24 | 18-24 | ? |
| PV/PF | vector | non/poor vector | vector | vector | vector |
| Sporozoite Rate | 0.51 | 0.04 | 0.30 | 0.40 | 0.46 |

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In Sri Lanka: *An.culicifacies*

Hitherto: only B occurred, and was the major vector.

Now: B and E have been identified (Surendran et al. 2000).

The both siblings occurred in:

Moneragala District (Pelawatta)
Puttalam District (Elivitiya)
Trincomalee District (Puliyankulam)

Only sibling E occurred in Badulla District (Aluthwela)

Based on the limited study done, E seems to be more common than B.

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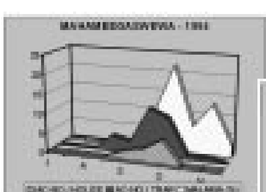
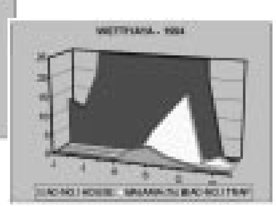
## Two riverine villages - different transmission patterns





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## *An. culicifacies* B and E

We have no precise information on

distribution
breeding ecology
biting habits
resting habits
vectorial capacity
insecticide resistance status

of these two sibling species in Sri Lanka.

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## *Anopheles subpictus*

Abhayawardana et al (1996) found sibling B in coastal areas only, and sibling A predominating in inland areas.

Sibling B is a brackish water breeding species, and has been implicated in malaria transmission in India.

Later, Abhayawardena et al. (1999) found that all 4 known sibling species (A,B,C,D,) occur in the Chilaw area of NW Sri Lanka.

Coastal site: 74% B

Inland site: 73% C

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## *Anopheles subpictus (cont.)*

Cattle-baited net traps:
Coastal site: 92% B
Inland site: 69% C

Cattle-baited huts:
Coastal site: 63% C
Inland site: 75% C

Indoor hand-aspirator collections:
Coastal site: 39% B, 45% C

Inland site: 80% C

Sibling C: MP sporozoite ELISA-positive

(Abhayawardena, unpublished data)

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## Other Species

*Anopheles annularis* :
Two siblings, Status in Sri Lanka unknown

*Anopheles barbirostris* :
Two siblings, status in Sri Lanka unknown

*Anopheles maculatus :*
Nine siblings, status in Sri Lanka unknown

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## Towards a Risk Map for Southern Sri Lanka: Results from the Uda Walawe Region

*Eveline Klinkenberg, Malaria Consultant, IWMI*

In the Uda Walawe region six Divisional Secretary Divisions (DSs) were selected: Embilipitiya, Thanamalvilla, Sevenagala, Angunukolapelessa, Ambalantota and Sooriyawewa. All confirmed malaria cases, for these areas, reported to the government health facilities were collected for the period January 1991-August 2000. Data were also collected from health facilities just outside the six DSs. Malaria data from private clinics were unavailable and therefore could not be included. For each GN[2] the malaria incidence (number of cases per 1000 inhabitants) was calculated for each month in the period January 1991-August 2000. These malaria incidences were mapped using GIS software (ARCVIEW)

The malaria incidence pattern showed:

- an overall high incidence in the Thanamalvilla DS throughout the years studied
- some GNs with high incidence along the Ratnapura road
- relatively low incidence in the rest of the area
- no clear seasonal pattern in malaria incidence over the years studied

A second step, which is still ongoing, is to relate the malaria incidence pattern to possible explaining factors. Information on the following parameters is available: land use, presence of water bodies (rivers, streams, tanks), rainfall, socioeconomic data (percentage of families receiving “Janasaviya” or food stamps, being landless, having electricity, ownership of a house), control measures (spraying, use of bed nets), soil moisture data (from satellite images). Additional data are needed on type of house construction and entomology.

The first results of the statistical analysis show that malaria incidence is high in the *chena* (slash and burn) areas and low in the paddy and other crop and plantation areas. This could partly be explained by the lower socioeconomic status of people in *chena* areas. At first sight it is surprising that GNs where insecticide house spraying takes place and where people use more mosquito control measures have a high incidence of malaria. However, it is likely that these malaria control measures take place because of the high density of mosquitoes and of malaria.

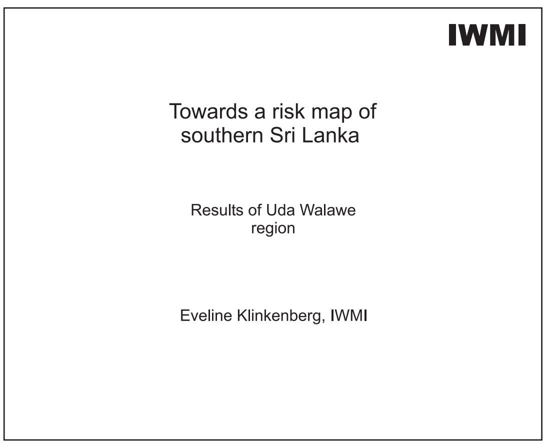
In Uda Walawe, *chena* cultivation is mainly practiced in the Thanamalvilla area. Comparing the presence of water bodies in the high and low incidence areas revealed that the Thanamalvilla area has a large number of abandoned tanks that are not present in the rest of the area. These tanks could serve as an additional breeding source for malaria vectors. During a field visit on

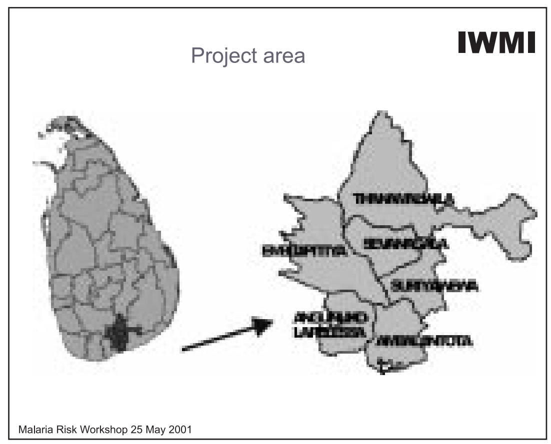
[2]GN is Grama Niladari, the smallest administrative unit in Sri Lanka.

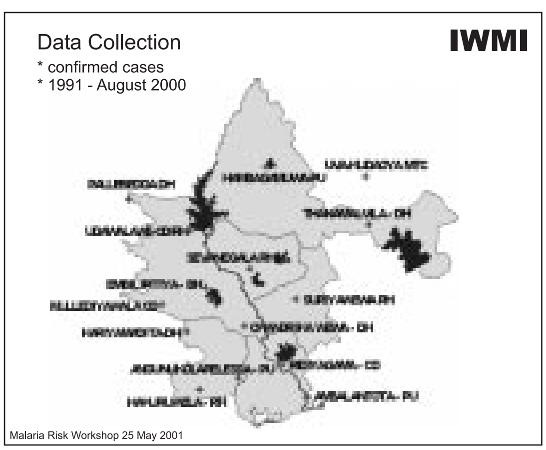
March 28, 2001 it was found that many of these tanks are, in fact, not abandoned but used by private users or groups of farmers. During this small survey of 8 tanks several anophelines were found breeding in the tanks (Klinkenberg 2001). The main vector for Sri Lanka, *An. culicifacies*, was not found, but several secondary vectors were identified, especially *An. annularis* and *An. vagus*. It could be that these secondary vectors are locally important in malaria transmission.

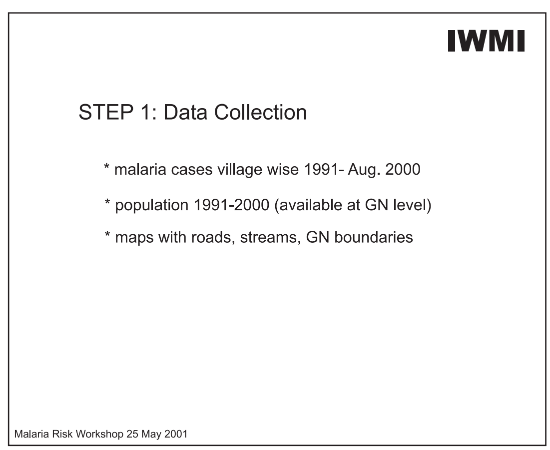
In the near future additional fieldwork will be carried out to investigate if there is a difference in the presence and density of vectors in high and low incidence areas.

*PowerPoint slides presentation*



**IWMI**

## STEP 2: MAPPING

* locate all “malaria villages”
  names recorded versus official villages names

* all villages located with aid of GPS
  double names, GN name

* all villages assigned GN by location/official list

* map malaria incidence (# cases/ 1000 inhabitants) per GN

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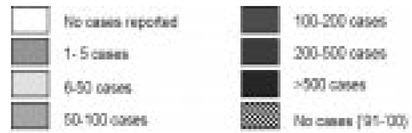
## Malaria per GN
## Uda Walawe area 1991-2000

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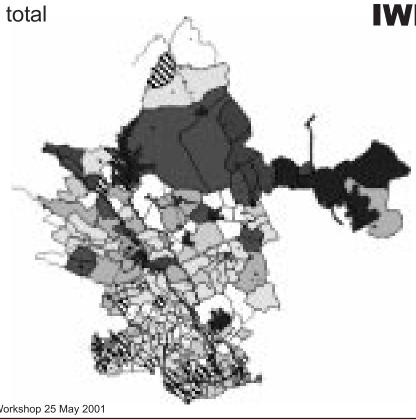
## 1991 total

**IWMI**



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### Main observations

* Thanamalvilla DS throughout years highest incidence

* Some high incidence GNs along Ratnapura road

* Relatively low incidence in rest of the area

* No clear seasonal pattern

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## Incidence maps can assist:

* Quick overview of data

* Targeting malaria control

## STEP 3: ANALYSIS

* relate malaria incidence to potential determinants
  (risk factors)

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## Collected parameters

* Land use (SD & LUPPD)

* Presence water bodies: rivers/streams/tanks (SD)

* Rainfall (MD, RS)

* Socio-economic data: %JS-FS, % landless, % electricity (C&S)

* Control measures (spraying, bednet) - incomplete (AMC/IWMI)

* Entomological data - few data only (AMC)

* Soil moisture (RS image)

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## Results

| Parameter | Criteria | Malaria incidence |
|---|---|---|
| % paddy per GN | <20% land cover<br>>20% land cover | 58<br>14 |
| % Abandoned tanks per GN | <1% land cover<br>>1% land cover | 25<br>74 |
| % families receiving JS or FS | <65% of families<br>>65% of families | 25<br>52 |
| Spraying activities per GN | Spraying<br>No spraying | 63<br>19 |
| Use of mosquito protection | Always<br>Never/sometimes | 18<br>8 |

JS =Janasavaya; FS = foodstamps

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## Problems data collection/restriction data set

* Most parameters only available for one year

* Data not always available at GN level

* Use of private hospitals
--> underestimate cases

* Chena not always clearly classified, scrub/forest areas also used for Chena

* Maps with different coordinate systems and boundary shapes

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## Additional data necessary

* Type of housing - no data

* Entomological data

* Bednet use - control measures

* % people going to private facilities
- underestimate - different per area

* Data from more rain stations

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## Characteristics Thanamalvilla area

* Mostly Chena cultivation

* Mainly scrub/forest area

* Little irrigation compared to rest of the area

* Large number abandoned tanks

Expect Chena area to be relatively dry, malaria confined to rainy season BUT no clear seasonal pattern visible

↳ Abandoned Tanks possible breeding source??

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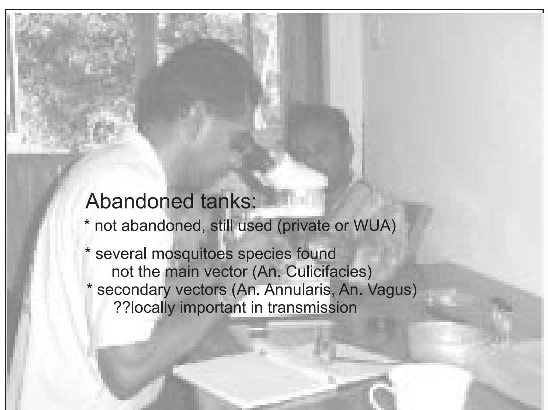


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## Summary Embilipitiya Workshop

Main risk factors:

- different per DSD
- pooling rivers/streams
- imported cases from Chena area (Thanamalvilla)
- importance of construction phase of irrigation projects

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## Role of risk mapping:

- Assist in planning malaria control
- More efficient use of resources
- Establishment TC and mobile clinics
- Identify risk factors

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## NEXT Step

- Complete statistical analysis
- Fieldwork to locate breeding sources and investigate vector importance in high and low risk areas

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## Surveillance and Its Use in Malaria Control in Sri Lanka

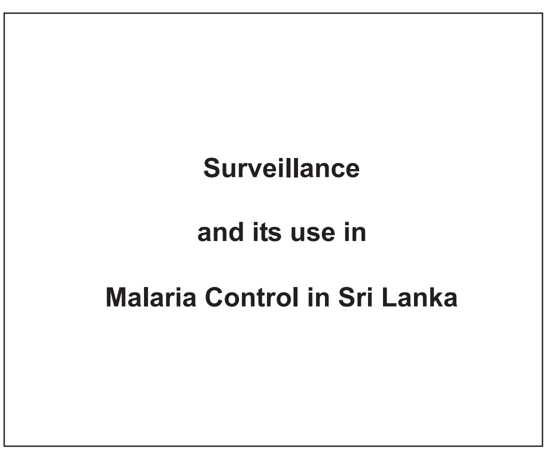
*Dr. A. R. Wickremasinghe*
*Senior Lecturer, University of Sri Jayawardenapura*

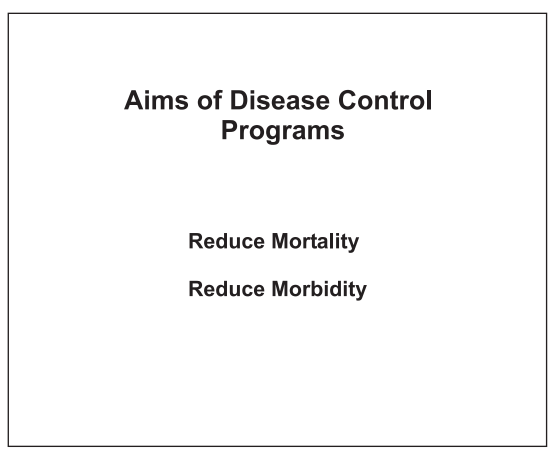
The primary objective of any disease control program is the reduction of morbidity and mortality. In order to prevent the occurrence of disease, a thorough understanding of the distribution of cases in a given geographic area is required. Surveillance is the ongoing systematic collection, analysis and interpretation of health data essential to the planning, implementation and evaluation of public health practice. In simple terms this means the collection of health data for action. Surveillance data can be used for planning future programs, implementation of plans, and monitoring and evaluation of activities. Surveillance is a cyclical process that involves collection of data, consolidation and evaluation of the data and dissemination of findings.

The major objective of the national malaria control program in Sri Lanka is the reduction of morbidity and mortality due to malaria. The strategies used to achieve these objectives include early diagnosis and prompt treatment of cases, selective use of integrated vector control methods, provision of chemoprophylaxis to high-risk groups, building and sustaining partnerships and community participation. Surveillance data is essential to the implementation, and monitoring and evaluation of these strategies.

The current surveillance system for malaria in Sri Lanka is a legacy of the eradication era. A number of deficiencies in the system have been highlighted, among which non-responsiveness to a control strategy, delays in the reporting system and the non-use of existing information in the planning process are the most important. A new computerized surveillance system is to be introduced rectifying some of the deficiencies in the current system.

*PowerPoint slides presentation*



## The Surveillance Cycle

- Collection of pertinent data in a regular, frequent and timely manner
- Orderly consolidation, evaluation and descriptive interpretation of data
- Prompt dissemination of findings

## Objectives of the National Malaria Control Program

- To reduce the incidence of malaria
- To minimize the proportion of *P.falciparum* nfections
- To eliminate mortality due to malaria
- To prevent malaria epidemics
- To prevent malaria in pregnancy

## Strategies Adopted

- Early diagnosis and prompt treatment
- Selective use of integrated vector control methods
- Chemoprophylaxis
- Building and sustaining partnerships
- Community participation

## How will surveillance help?

- Early diagnosis and prompt treatment
  - Distribution of cases
  - Establishment of malaria diagnosis and treatment centers
  - Detect epidemics
  - Proportion of *P. falciparum* infections
  - Drug resistant malaria

## How will surveillance help?

- Selective use of integrated vector control
  - Identify high risk areas
  - Distribution of vectors
  - Identify areas for vector control
  - Monitor and evaluate the vector control programme

## How will surveillance help?

- Chemoprophylaxis
  - Identify high risk groups
  - Monitor Chemoprophylaxis programme
- Building partnerships and Community Participation
  - Monitoring and evaluation

## Current Surveillance System for Malaria in Sri Lanka

- Legacy of the eradication era
- “Reactive” rather than “Pro-active”
- Does not address current problems
- Reporting by place of diagnosis rather than place of residence/transmission
- Delays
- No feedback
- Not optimally used for planning purposes

## Proposed changes

- Computerized system
- Weekly reporting system
- Reporting by place of residence (GN level)
- Additional data to be obtained
  - Treatment failures
  - Chemoprophylaxis
  - Investigation of cases/deaths

## Anticipated Benefits

- Detect changes in incidence early
- Useful tool in planning malaria control activities
- Tool in the decision making process
- Establish a dialogue between Regional Malaria Officers
- Reduction in the morbidity and mortality i.e., burden of disease in the community

## Use of GIS and Remote Sensing Tools for Malaria Research and Control

*Lal Mutuwatta, GIS & RS Specialist*
*and*
*Eveline Klinkenberg, Malaria Consultant, IWMI*

Computerized information management systems incorporating Geographic Information Systems (GIS) provide a powerful means of capturing, storing and displaying spatial information. It would be a useful tool for evidence-based decision making in malaria control. This technology could be used in identifying risk areas and risk factors, stratification for malaria interventions, allocation of limited resources in a cost-effective manner and forecasting epidemics or identifying sudden outbreaks. A microepidemiological study of malaria conducted in southern Sri Lanka used GIS technology to display house type distribution and incidence rates in relation to different house types. In this study, GIS was used to generate nearest distance between houses and bodies of water and forest edges, and to create a buffer zone around water bodies. Finally, the findings were used to estimate the impact of malaria risk reducing interventions (Gunawardena et al. 1998). In a study in India (Mutuwatta et al. 1997) GIS techniques were used to correlate malaria, irrigation density, rainfall and rice intensity making use of Thiessen Polygons.

Remote sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation. This tool can be used in studies of disease transmission and vector ecology. There are many earth-observing satellites and the features of some commonly used satellites in health studies are given below:

| SATELLITE | Temporal Resolution (d) | Spatial Resolution (m) | Remarks |
|---|---|---|---|
| NOAA | | | |
| AVHRR | Daily | 1,000-4,000 | Free, low resolution |
| SPOT | 2-7 days | 2.5-20 | US$ 2500 |
| LANDSAT | 16 | 15, 30, 60 | US$ 600/image-(180kmX180km) |
| Ikonos | 8-14 days | 1-5 | US$ 3000 - Suitable for detailed information |
| Terra ASTER | 16 days | 15-90 | US$ 100 on request (60kmx60km) |

In many malaria studies remotely sensed data have been used to derive vegetation cover, landscape structures and water bodies. Remotely sensed factors have potential links with malaria, especially vector habitat and vector survival.

Potential links between RS factors and malaria

| Factor | Opportunity |
|---|---|
| Vegetation/crop type | Breeding/resting/feeding habitats |
| Vegetation development | Timing of habitat creation |
| Permanent water | Mosquito habitat |
| Flooding/flooded forests | Mosquito habitat |
| Soil moisture | Mosquito habitat |
| Wetlands | Mosquito habitat |
| Rivers/streams/canals | Dry season mosquito-breeding habitat |

Remotely sensed data have been used in malaria research. In a study carried out in Mexico, LANDSAT-TM satellite derived information was used to characterize and detect larval habitats (Beck et al. 1994) and in a study conducted in Belize, SPOT data were used to predict vector densities based on distances to larval habitat (Rejmankova et al. 1995). In a Kenya study, satellite images were used to predict key malaria transmission factors such as biting rates and Entomological Inoculation Rates (EIRs), using NDVI and modeled Soil Moisture (Patz et al. 1998).

## Development of an Epidemic Forecasting System for Malaria in Sri Lanka by Monitoring Remotely Sensed Soil Moisture Data

*Dr. D.M. Gunawardena*
*Research Associate, IWMI*

Malaria continues to be a major public health problem and the leading cause for hospital admissions in many disease endemic countries. The disease hinders the general development of poor rural communities who are mainly dependent on an agricultural livelihood. One of the difficulties in reducing malaria transmission risk is the lack of prior information on transmission potential in space and time. Therefore, there is a clear need for developing an effective and simple forecasting system of malaria transmission that could be incorporated into decision-support systems for malaria control. Such a system could be feasible and give adequate time for preparing for the prevention and control of transmission. It would also provide timely information for a rapid response and will alert and assist planners, program managers and policy makers in their planning process and implementation of a successful prevention and control program. Prediction of malaria outbreaks/ epidemics in advance would facilitate the allocation of resources in a cost-effective manner with savings to both the government and the individuals, alert populations on transmission risks and introduce preventive measures through health education campaigns.

There have been some efforts to develop systems for predicting malaria transmission through indoor resting densities of vectors (Lindblade et al. 2000), biting and entomological inoculation rates and modeled soil moisture (Patz et al. 1998). Malaria control services, however, have still neither developed nor used a successful mechanism to predict malaria transmissions in advance (WHO 1998). The Water, Health and Environment Theme of IWMI initiated a study on mapping malaria risk and development of an epidemic forecasting system by monitoring remotely sensed routine soil moisture in the Moneragala district of Sri Lanka. The soil moisture ($cm^3/cm^3$) data derived from NOAA (National Oceanic Atmospheric Administration) images gives clues on availability of surface water that could be favorable for breeding of malaria vectors. In this study, Grama Niladhari (GN) level malaria incidence of Moneragala district on a 10-day basis from June 1999 to July 2000 were correlated with 40 days lagged soil moisture. The preliminary data analysis did not reveal a significant relationship between soil moisture and malaria incidence. The outcome could have been constrained by the following: 1) though there are many factors involved in malaria transmission we considered only one factor (soil moisture index) for the data analysis; 2) the low-resolution images used could not be adjusted to fit exactly with some small GN areas; 3) soil moisture data were only available for a one-year period and were present for the latter part of the epidemic and 4) in some areas, case data were unavailable or not represented due to lack of diagnostic facilities or patients seeking treatment from private facilities. Therefore at the next stage of data analysis w**e** need to consider more specifically other geographical and environmental factors that influence malaria transmission such as NDVI (normalized difference vegetation index), surface temperature, land use pattern etc. The factors derived from high-resolution images in conjunction with long-term epidemiological and entomological data series of known high-risk areas will be useful for the development of an epidemic forecasting system for malaria.

**IWMI**

## Use of GIS and remotely sensed data for malaria control

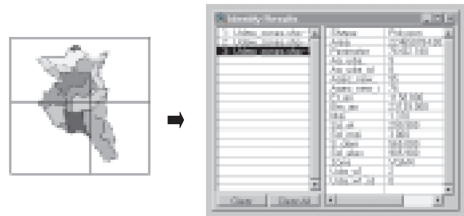
Lal Mutuwatta,Eveline Klinkenberge
and D.M Gunawardena

National Workshop on Mapping Malaria Risk - 2001.05.25

**IWMI**

## What is GIS?

A computer assisted information management system of geographically referenced data



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Use of GIS

- GIS would be a useful tool for evidence based decision making.
  - In identifying risk areas and risk factors.
  - In stratification for interventions
  - Use of limited resources in a cost-effective manner.
  - In forecasting epidemics or identifying sudden outbreaks.

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**IWMI**

Applications

Microepidemiological study of malaria in Southern Sri Lanka

Gunawardena et.al, 1996

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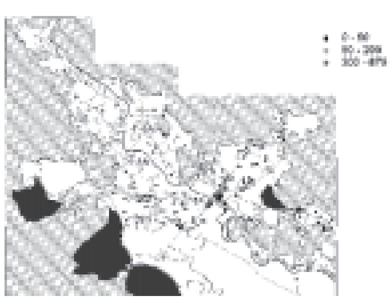
Malaria Incidence Rates

**IWMI**



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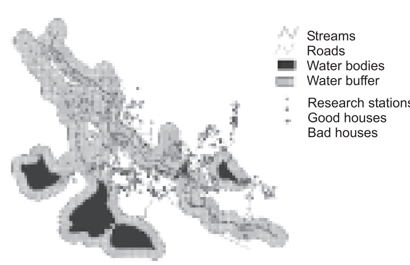
**IWMI**

Buffer Zone of 200 meters around Water Bodies



**IWMI**

## Malaria risk in the two house types in relation to their distance from a source of water

| Distance from Water (M) | Malaria incidence rates (no of houses) in houses of construction type | |
|---|---|---|
| | Good* | Poor* |
| 0 - 100 | 41.5(47) | 189.1(52) |
| 101 - 200 | 36.1(42) | 125.6(37) |
| 201 - 400 | 68.5(38) | 92.0(52) |
| >400 | 62.0(34) | 91.3(47) |

*Spearman correlation coefficient r=0.14; p=0.0676 for good houses and r=-0.13; p=0.0001 for poor houses.



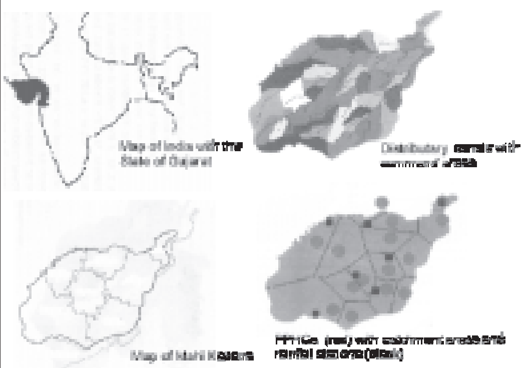
**IWMI**

Water related environmental factors and
Malaria transmission
In Mahi Kadana, Gujarat, India

Muthuwatta et.al 1997

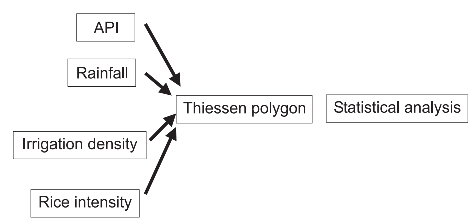


**IWMI**






**IWMI**






**IWMI**

Correlation coefficients between variables aggregated at PPHC catchment for 1981

| | Rainfall | Irrigation density | Rice intensity |
|---|---|---|---|
| Ln(API) | 0.77 ( P = 0.001) | 0.412 ( P = 0.127) | 0.56 ( P = 0.028) |



**IWMI**

## What is Remote sensing ?

Remote sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation

**IWMI**

NOAA
AVHRR
(Advanced Very High Resolution Radiometer)
Image Receiving System at the Department of Meteorology, Colombo.

Antenna diameter - 2 m
PC based
networked system

Risk Mapping Workshop- March 29, 2001

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**IWMI**

Annual actual evapotranspiration (mm)
June 1999 to May 2000

Soil moisture ($cm^3/cm^3$)
May - 2000

Risk Mapping Workshop- March 29, 2001

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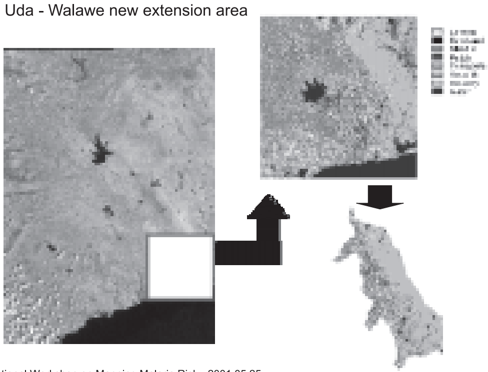
**IWMI**

Land cover classification of
Uda - Walawe new extension area



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**IWMI**

## Some features of current sensor systems

| Satellite | Temporal Resolution (d) | Spatial Resolution (m) | Remarks |
|---|---|---|---|
| NOAA AVHRR | 4--6 times daily | 1,000-4,000 | Free-low resolution |
| SPOT | 2-7 days | 2.5-20 | 2500 US$ |
| LANDSAT | 16 | 15,30,60 | 600 US$/image-(180kmX180km) |
| Ikonos | 8-14 days | 1-5 | 3000 US $ - Suitable for detail information |
| Terra ASTER + | 16 days | 15-90 | 100 US on request (60kmx60km) |

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**IWMI**

## Use of RS in malaria

- Research
  - vector ecology
  - disease transmission
- Control
  - monitoring patterns of malaria transmission
  - early warning or predicting epidemics
  - planning control strategies (Mapping risk/stratification, resource allocation)

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## Variables that could be obtain from RS

- Landscape structures
- Vegetation cover
- Water bodies

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## Potential links between RS factors & Malaria

| Factor | Opportunity |
|---|---|
| Vegetation/crop type | Breeding/resting/feeding habitats |
| Vegetation green-up | Timing of habitat creation |
| Permanent water | Mosquito habitat |
| Flooding/flooded forests | Mosquito habitat |
| Soil moisture | Mosquito habitat |
| Wet lands | Mosquito habitat |
| Rivers/streams/canals | Dry season mosquito-breeding habitat |



IWMI

## Applications of RS

- Mexico (LANDSAT_TM)
  - Characterization and detection of larval habitat
- Belize (SPOT)
  - Prediction of vector densities based on distances to RS larval habitat
- Kenya (NOAA-AVHRR)
  - Predicting key malaria transmission factors, biting and EIR, using modelled Soil Moisture

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## Other Directions

- Plankton bio mass
  - Breeding habitat
- Human settlement patterns/forest edges
  - migration & malaria risk
- Crop types
  - effects of pesticides (vector resistance)
- Cold Cloud Duration
  - risk of epidemics

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## Contd.

- Surface temperature
  - vector survival
- Urban features(house types)
  - identify high risk areas/interventions

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## Development of an epidemic forecasting system for malaria using Remotely sensed soil moisture data

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## Disease forecasting system

- Provide adequate time for the preparedness
- Improve prevention and control capabilities
- Focus control efforts
- Select appropriate interventions
- Alert and educate public on prevention

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## Routine soil moisture monitoring for epidemic forecasting

IWMI

Soil moisture(SM): surface water availability (cm3/cm3) and it indicated suitable habitat for mosquito larvae.

(NOAA images-June 1999-May 2000)

Correlated GN level malaria incidence(MI) with soil moisture.

The lag period between SM and MI was 40 days.

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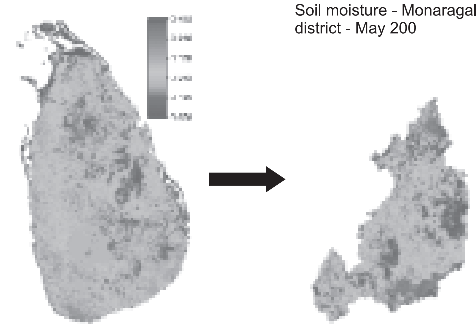
IWMI

Soil moisture - May - 2000

Soil moisture - Monaragala district - May 200



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IWMI

Data analysis still in progress

Preliminary results did not showed a relationship between SM and malaria incidence.

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IWMI

## Deficiencies

- Use of one veriable
- Low resolution images (1000-4000 m)
- Quality of case data
  - Under reporting
  - One year

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IWMI

## Opportunities

- Consideration of other environmental factors (NDVI, Surface temperature, land use pattern)
- Use of high resolution images (if possible)
- Long term data series
- Select reliable case data
- Entomological data (LD, IRD etc.)

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IWMI

What are the possibilities of applying GIS /RS for malaria research and control in Sri Lanka or in your region?

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# DISCUSSION

***Led by Dr. Felix Amerasinghe***

Dr. Felix Amerasinghe opened the discussion with the questions:

> Would risk mapping be of use to you in your area of work?
> Would the RMOs see risk mapping as a benefit to their work?

Dr. Felix Amerasinghe went on to say that the questions asked at the Uda Walawe workshop[3] could also be asked here, although the Uda Walawe workshop was different in its approach and presentation. For instance, would the RMOs have sufficient entomological information for their area and what is the information that is available on surface water accumulations, rivers/streams, tanks, cultivation patterns etc. If this information was available with the RMOs, they could be provided with digitized maps of their area to compile risk maps. It was stated that forecasting of epidemics is different from risk mapping, but uses the same tools.

Dr. Gunawardena was carrying out research in the Moneragala District where all available information would be incorporated in a map of the area and the data used to firstly develop a risk map and secondly develop prediction patterns. Dr. Felix Amerasinghe inquired whether this kind of work had been done in other areas apart from Moneragala.

From the discussion it emerged that risk mapping was not operational in any of the regions, but there was interest in developing this capability. For instance, Mr. Ranjith de Alwis, RMO of Polonnaruwa stated that there had not been many malaria cases in the Polonnaruwa District for the last 6-7 years. However, he was interested in a mapping exercise incorporating the available malaria incidence information, irrigation systems, malaria estimates, spreading patterns etc. The lack of facilities prevented them from carrying out such research. Ms. Devika Perera, RMO of Anuradhapura inquired whether a risk map could be generated with the past entomological data available with them. She said Anuradhapura had data for 6-10 years, collected from six sentinel sites. Dr. Felix Amerasinghe stated that if there was reliable data for the past six years for Anuradhapura, IWMI could consider extending the project to Anuradhapura, because one of the problems at Moneragala was that the available entomological data were scattered and not continuous.

Ms Peiris, RMO of Hambantota stated that in Lunugamvehera there was an association between water bodies and malaria and that most malaria cases were reported from the Kirindi Oya upstream close to the Moneragala boundary and upstream of the Uda Walawe-Samanala Wewa area.

Mr. Premasiri, the RMO of Puttalam said that in his area there were only major irrigation systems, and no minor irrigation works, but that they did find malaria in these major irrigation areas in contrast to what was found in Uda Walawe.

Mr. Munasinghe, RMO of Embilipitiya stated that apart from land use and other environmental factors, an important factor to take into account was also the breakdown of the health system management. Moneragala has a lot of cases but for quite some time there was no RMO present in the area and there was a lack of resources. Factors like this should also be considered when analyzing high and low-risk areas.

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[3]See Klinkenberg, E., 2001.

The question was raised whether data collected for one year could be used for developing a risk map. Dr. Felix Amerasinghe stated that while this was possible, data over several years would give a clearer picture of risk patterns over time.

During the discussions it transpired that although the RMOs had been provided with computers, they were not trained in the use of GIS software. The question arose as to who could be trained in the use of such GIS software—whether it had to be the RMO or some other member of his staff. It was pointed out that the RMO due to government restrictions could not hire people from outside to work on computers. At present it was difficult for them to even obtain the services of a data entry operator. As such, what they needed was some support from an organization like IWMI.

Dr. Felix Amerasinghe stated that if the Ministry's plans to introduce a computerized malaria surveillance system were serious, then GIS-based risk mapping could be added giving careful consideration to the number of staff required and training needs in computer use and software etc. The risk mapping that IWMI had already done was based on epidemiological data from three Divisions but the analysis carried out so far using GIS was basic. IWMI was aware that many different types of analyses could be done. However, all areas in the country would not be like Thanamalvilla or Walawe and as such IWMI could introduce risk mapping as a separate project. This project could be included into the RBM program as a GIS training component in Sri Lanka. However, the support of both the AMC and the WHO was needed to work out such a project.

Dr. Wim van der Hoek stated that there was a GIS software program, namely Epi Map, which could be downloaded free from the Internet. He stated that the Epi Map program was simpler to use than the sophisticated GIS programs available and that it would be sensible for RMOs to use such a software to map malaria incidences in their area. Basic training in the use of Epi Map could be provided by IWMI. It turned out that some RMOs already had received copies of Epi Map and that the new surveillance system developed by Dr. Wickremasinghe is based on Epi Map. This would be introduced in the second half of this year to all health units.

Dr. Fernando stated that it would be ideal if IWMI could conduct a training program since the expertise was available. For this a project could be developed for funding. IWMI representatives confirmed that this would be possible. Such a project could take the form of a few staff members from the AMC being sent to IWMI for basic training and drawing of maps. Once the maps were drawn, they could be taken back to the RMOs to incorporate the regional information available with them. The other alternative was to source the map drawing to an outside agency while IWMI would conduct a training program for the RMOs to use the GIS software package.

If such a project could be implemented, then a decision had to be made as to what sort of maps would be required; whether it would be at DS level or GN level. Digitized maps at DS level were already available with IWMI. It was felt that maps at GN level should be available at the local level, mostly as sketch maps i.e., not geo-referenced. The RMOs stated that they had already provided Dr. Wickremasinghe with hand drawn maps showing the GN Divisions, following a Workshop held in November 1999, but stated that none of these maps were geo-referenced.

Lal Muttuwatta stated that if the sketches were available incorporating this information into the DS maps would be possible but geo-referencing them would take quite some time depending on the quality of the sketches.

Dr. Felix Amerasinghe explained that IWMI had managed to develop a map for the Uda Walawe area and the Moneragala District that reflected the geo-referenced GN Divisions. If an RMO would be interested in working with the basic data available for GIS work, IWMI would be ready to help since a basic model has already been developed. However, it was emphasized that the data collection would be the responsibility of the RMO of the District and IWMI's role would only be to incorporate the data and develop the maps on the parameters available or requested. Dr. Felix Amerasinghe also suggested that the PHIs working in the areas should be involved in collecting data since they had personal knowledge and experience about malaria occurrences and its relationship to the habitat, vegetation etc. The Yan Oya study was an example of how the PHI was able to provide IWMI with information on malaria transmission.

Dr. Felix Amerasinghe also stated that Dr. Gunawardena was working on relating soil moisture to malaria incidences in the Moneragala District. The soil moisture maps were obtained from the Meteorological Department and attempts were being made to relate soil moisture to malaria incidence. Dr. Wim van der Hoek indicated that a soil moisture study would be more productive in a country such as Africa rather than Sri Lanka since development of water bodies would be easier to monitor in dry Savanna areas than in more densely vegetated areas like in Sri Lanka.

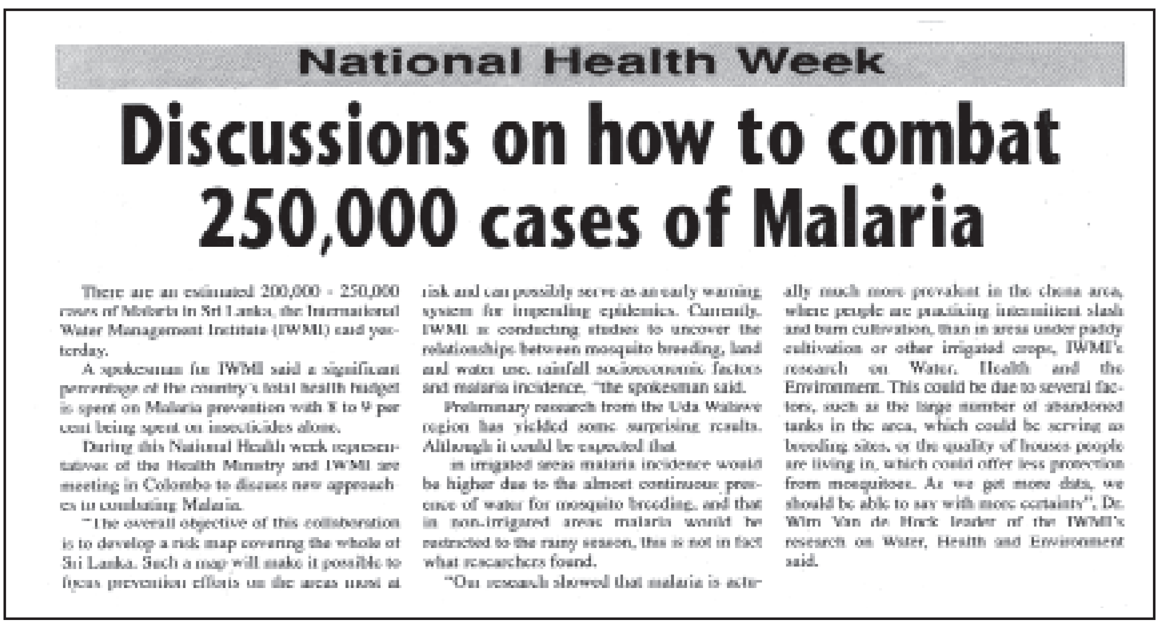
Dr. Fernando inquired whether the Meteorological Department would provide different types of data on request. Lal explained that the Meteorological Department recorded data on a daily basis and they would provide it in either digital or electronic form on request. The Health Ministry could probably enter into an agreement with the Meteorological Department for provision of this data at special rates.

Regarding vector importance Ms Handhunnetti stated that *An. vagus* could be important as a vector through its high numbers. In general only a low infection rate is found in this species; however it can occur in very high numbers which could still lead to significant transmission.

Two important outcomes of the discussion were:

1. Dr. Gunawardena undertook to develop a proposal incorporating GIS/RS and field based studies to identify risk areas and develop control strategies in the Moneragala District, especially the Thanamalvilla DS. This would be forwarded for priority funding to WHO as a joint proposal between IWMI and the AMC.

2. In discussions Dr. Felix Amerasinghe, Dr. Fernando (Director AMC) and Mr. Piyatilleke (DRPM [4] Agriculture-Mahaweli Project, Walawe) agreed that the AMC would reserve bednets for provision to settlers in the newly developed Left Bank Extension area of the Walawe Irrigation Scheme during the course of 2001-2002. This would be further coordinated by direct official contacts between the Mahaweli Authority-Walawe and the AMC.



National Health Week

# Discussions on how to combat 250,000 cases of Malaria

There are an estimated 200,000 - 250,000 cases of Malaria in Sri Lanka, the International Water Management Institute (IWMI) said yesterday.

A spokesman for IWMI said a significant percentage of the country's total health budget is spent on Malaria prevention with 8 to 9 per cent being spent on insecticides alone.

During this National Health week representatives of the Health Ministry and IWMI are meeting in Colombo to discuss new approaches to combating Malaria.

"The overall objective of this collaboration is to develop a risk map covering the whole of Sri Lanka. Such a map will make it possible to focus prevention efforts on the areas most at risk and can possibly serve as an early warning system for impending epidemics. Currently, IWMI is conducting studies to uncover the relationships between mosquito breeding, land and water use, rainfall socioeconomic factors and malaria incidence, "the spokesman said.

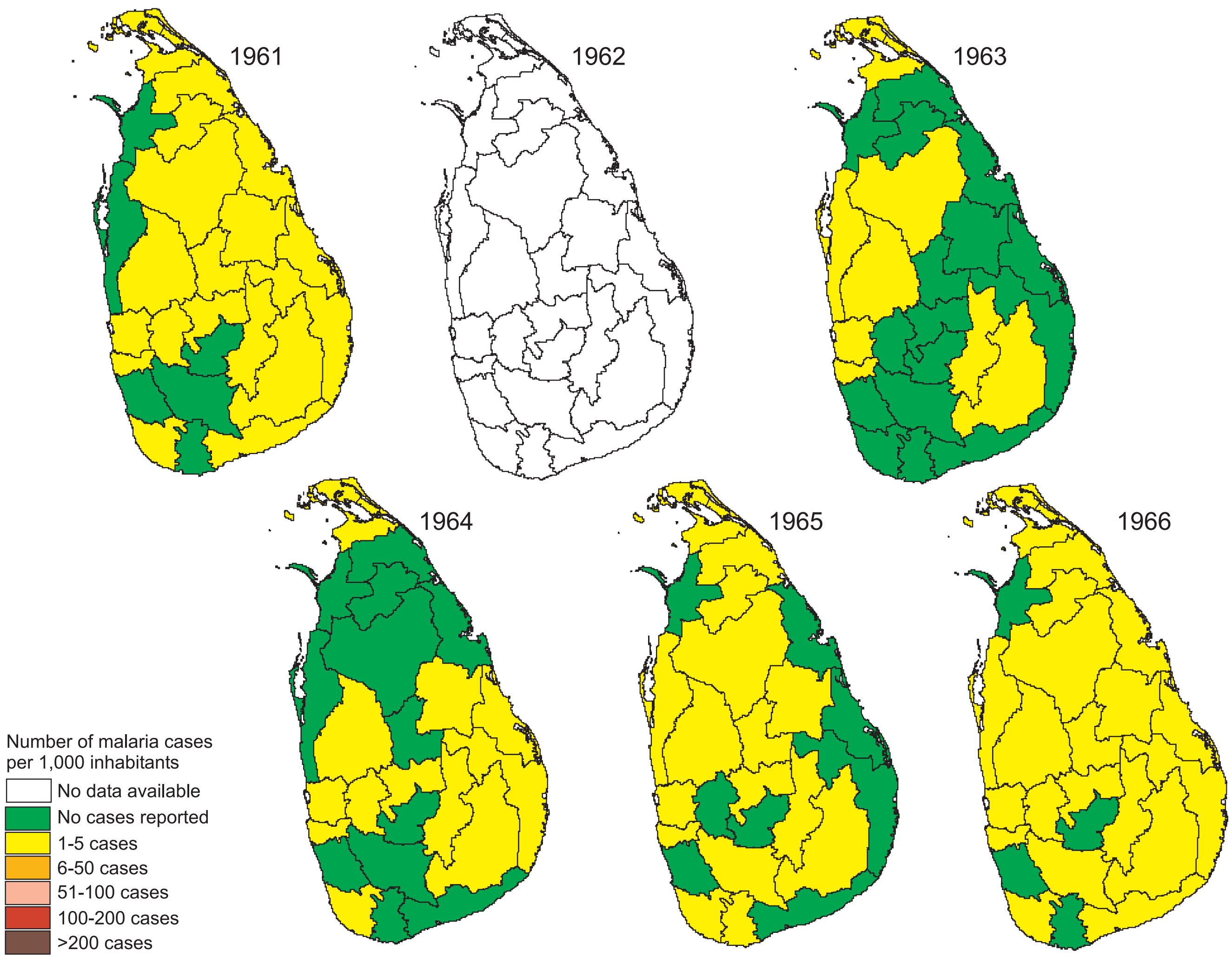
Preliminary research from the Uda Walawe region has yielded some surprising results. Although it could be expected that

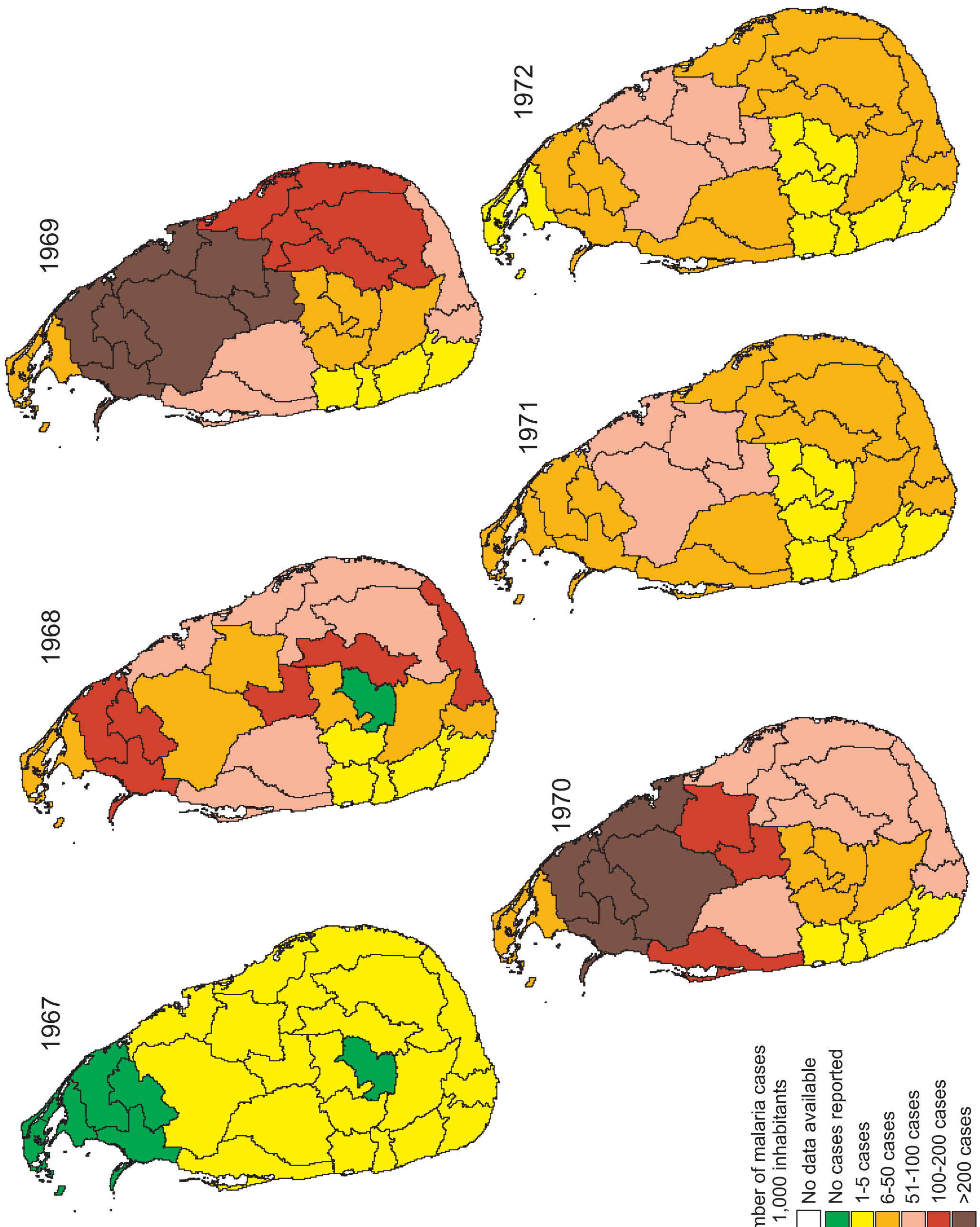
in irrigated areas malaria incidence would be higher due to the almost continuous presence of water for mosquito breeding, and that in non-irrigated areas malaria would be restricted to the rainy season, this is not in fact what researchers found.

"Our research showed that malaria is actually much more prevalent in the chena area, where people are practising intermittent slash and burn cultivation, than in areas under paddy cultivation or other irrigated crops, IWMI's research on Water, Health and the Environment. This could be due to several factors, such as the large number of abandoned tanks in the area, which could be serving as breeding sites, or the quality of houses people are living in, which could offer less protection from mosquitoes. As we get more data, we should be able to say with more certainty", Dr. Wim Van de Hoek leader of the IWMI's research on Water, Health and Environment said.

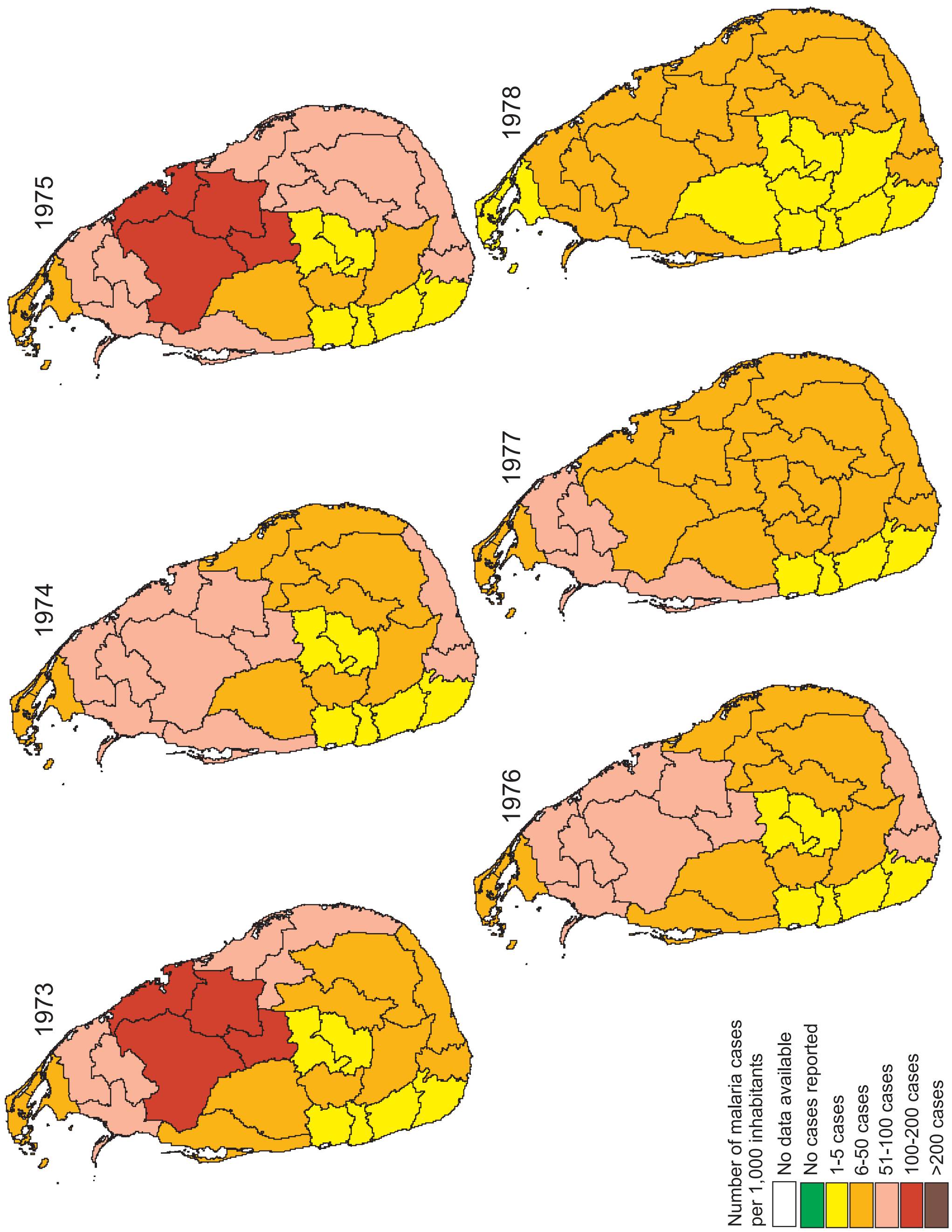
[4]Deputy Resident Project Manager.

*District wise malaria incidence in Sri Lanka 1961-1990*





1967
1968
1969
1970
1971
1972
Number of malaria cases
per 1,000 inhabitants
No data available
No cases reported
1-5 cases
6-50 cases
51-100 cases
100-200 cases
>200 cases


1973
1974
1975
1976
1977
1978
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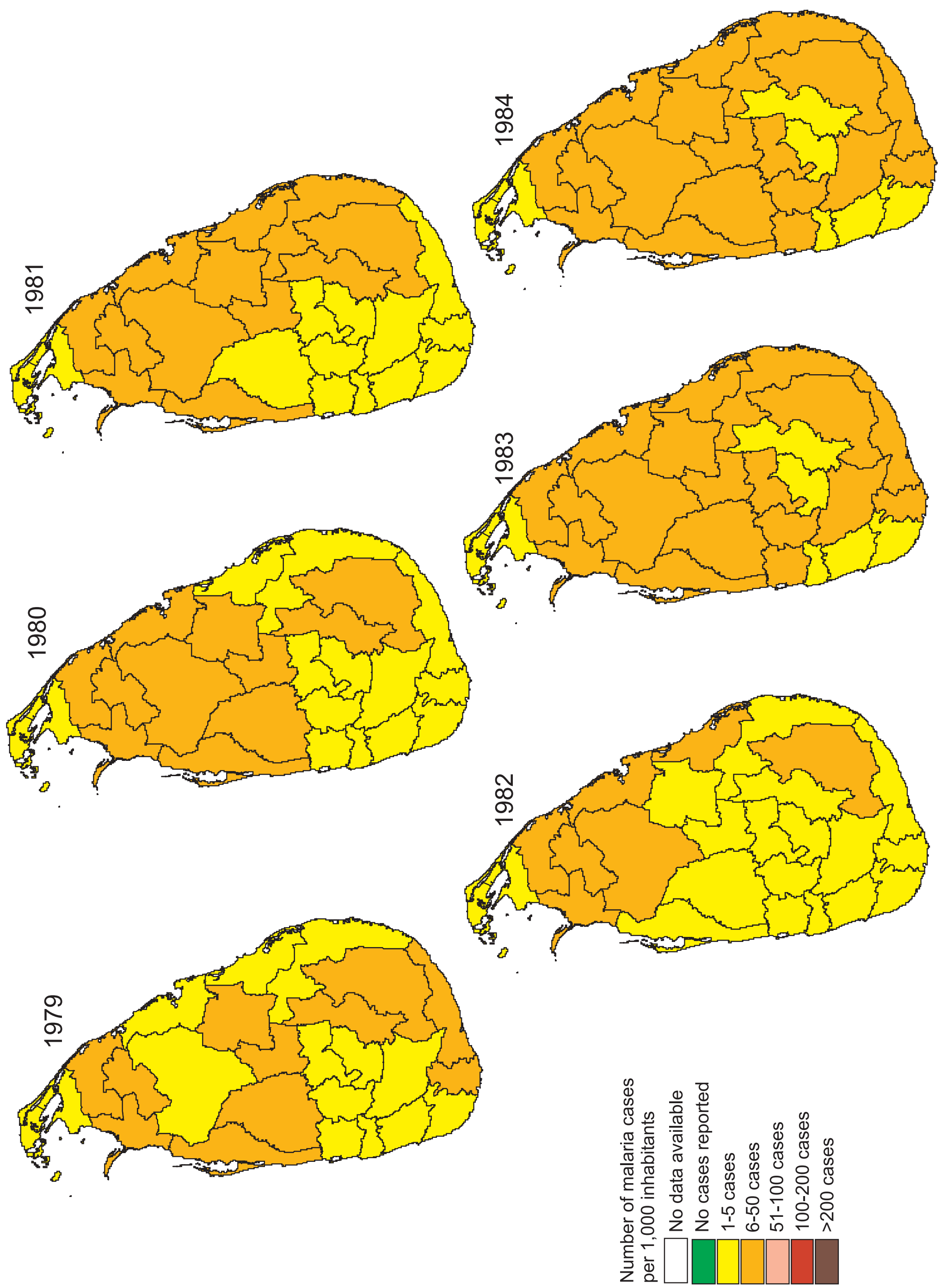
1979
1980
1981
1982
1983
1984
Number of malaria cases
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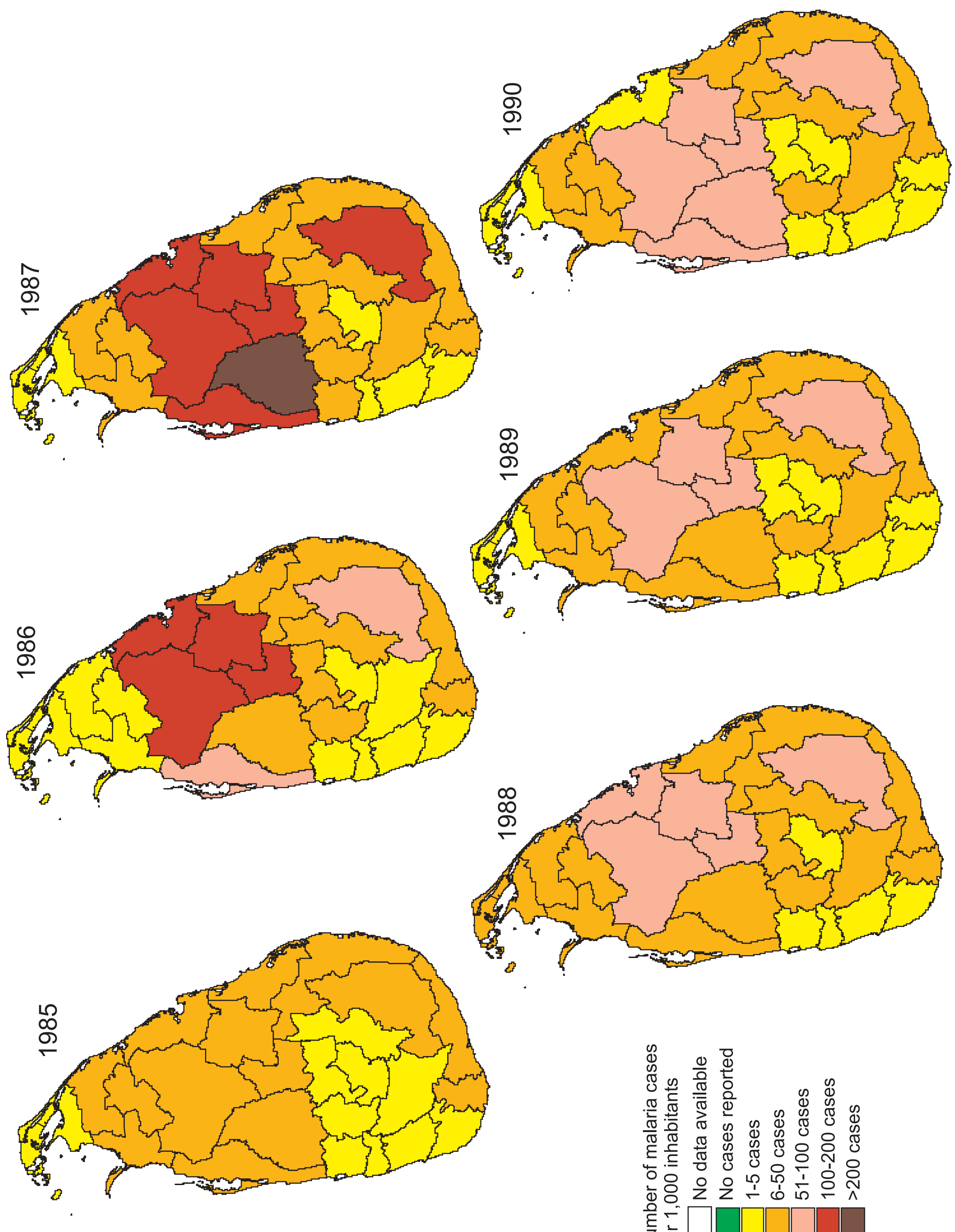

1985
1986
1987
1988
1989
1990
Number of malaria cases
per 1,000 inhabitants
No data available
No cases reported
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