WORKING PAPER 21

Malaria Risk Mapping in Sri Lanka—Results from the Uda Walawe Area

Proceedings of a Workshop held in Embilipitiya, Sri Lanka 29th March 2001

Eveline Klinkenberg, Editor

International Water Management Institute

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

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IWMI gratefully acknowledges the support for its work on vector control by the Government of Japan.

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Cover photograph: Kukul Katuwa Wewa, an abandoned tank in the Thanamalvilla area in Sri Lanka by Eveline Klinkenberg

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

Contents

1. INTRODUCTION

This working paper contains the proceedings of the workshop on "Malaria Risk Mapping in Sri Lanka—Results from the Uda Walawe Area" that was held on March 29, 2001 at the Hotel Centauria in Embilipitiya. The objective of the Workshop, organized by IWMI's Water, Health and Environment Theme, was to discuss the results of the malaria risk mapping work carried out to date in the Uda Walawe area, with the collaboration of staff involved in malaria control work in the area and from the Divisional Secretaries and Land use planning Offices. These staff were invited to participate in the Workshop.

The main objectives of the workshop were to:

1. Present and discuss the results of the research findings of the malaria risk mapping project in the Uda Walawe region.
2. Discuss the malaria pattern in the Uda Walawe region.
3. Discuss the possible risk factors in the different Divisional Secretary Divisions (DSDs).
4. Discuss the role that risk mapping could play in planning of malaria control activities.
5. Discuss and present IWMI's research in Southern Sri Lanka

An important aspect of the workshop was the discussion of the results with the participants. These discussions (see chapter 5 & 6) provided an important feedback to the results of the project and also provided additional insights into the underlying factors influencing the observed malaria pattern.

2. WORKSHOP PROGRAM

Time	Topic	Speaker
09:30 hrs. to 09:50 hrs.	Welcome and Introduction to IWMI	Dr. Felix Amerasinghe, IWMI
09:50 hrs. to 10:00 hrs	Objective of the Workshop	Dr. D. Gunawardena, IWMI
10:00 hrs. to 10:10 hrs.	Malaria Pattern in Embilipitiya	Mr. N.B. Munasingha, RMO, Embilipitiya
10:10 hrs. to 10:40 hrs.	Malaria Vectors in Sri Lanka: Sibling species and their role in malaria transmission	Dr. Felix Amerasinghe, IWMI
10:40 hrs. to 11:00 hrs.	TEA	
11:00 hrs. to 11:45 hrs.	IWMI research in Southern Sri Lanka	Dr. Wim van der Hoek, IWMI
11:45 hrs. to 12:15 hrs.	Malaria surveillance and spatial targeting of interventions	Dr. D. Gunawardena and Mr. Lal Mutuwatte, IWMI
12:15 hrs. to 13:00 hrs.	Findings of the Malaria Risk Mapping Study	Ms. Eveline Klinkenberg, IWMI
13:00 hrs. to 14:00 hrs.	LUNCH	
14:00 hrs. to 15:00 hrs.	Group Assignment [one group per DSD – average 10 persons]	
15:00 hrs. to 15:15 hrs.	TEA	
15:15 hrs. to 16:30 hrs.	Group presentations [15 minutes per group]	
16:30 hrs. to 17:00 hrs.	Discussions and conclusions	All participants

Group Assignment

All participants were grouped according to their Divisional Secretary Divisions: Sooriyawewa, Embilipitiya, Angunukolapelessa, Ambalantota, Thanamalvilla/Sevenagala, totaling five groups. Following lunch, the groups met to discuss among themselves the questions raised below. One hour was assigned for the group work and each group was provided with a map of their DSD with Grama Niladari (GN) boundaries indicated, to use for their presentation and discussion.

Questions addressed in the group work:

1. Is it possible to identify high risk areas for malaria in the Division?
2. If yes, which s are the high risk areas? [Please indicate on map provided.]
3. Are there known environmental risk factors in the Division, i.e. certain surface water sources, vegetation and cultivation patterns, gem mining, etc. Where are they located?
4. Could risk mapping play a role in planning of malaria control activities in the Division?
5. Explain how.

During the hour every group prepared a small summary of their relevant DS Division which was then presented to the rest of the groups in a short presentation of 10 minutes per group. Five minutes were allocated for discussion. The presentations and discussions of all the groups were followed by a general discussion, among all the participants, for the whole area.

3. RISK MAP PROJECT OUTLINE

The overall project objective is to develop a risk map for malaria covering the whole of Sri Lanka. Such a map would make it possible for the relevant Health Divisions to better target their malaria control activities to high-risk areas and prepare themselves for impending epidemics. Apart from a general focus on the whole island, several areas are to be studied in detail to find if a relationship exists, at micro scale, among mosquito development, malaria incidence, land use and meteorological features. As a first step to developing such a map, a risk-mapping project was carried out in the Uda Walawe region. Apart form this project, IWMI's Water, Health & Environment Theme is carrying out several other projects in Sri Lanka to study in more detail the interaction between mosquitoes and their environment.

Uda Walawe Area

For this study six Divisional Secretary Divisions (DSDs) in the Uda Walawe area were selected: Embilipitiya, Thanamalvilla, Sevenagala, Angunukolapelessa, Ambalanatota and Sooriyawewa. These areas were mapped at Grama Niladari (GN), the smallest administrative boundary in Sri Lanka, level, with the available data of malaria cases for the period 1991-2000 that were reported to the health facilities within the 5 DSDs. Plotting of these cases on maps showed the areas with high and low malaria incidences, which would allow for targeting of malaria control activities in the future. These malaria incidence patterns were related to possible parameters such as presence of irrigation, land use, anti-mosquito measures (e.g. bednets/coils), meteorological data (rainfall/ humidity), control activities (e.g. house-spraying), socio-economic status, presence of cattle etc.

Moneragala Area

A study similar to the study carried out in the Uda Walawe region is being undertaken in the Moneragala District, one of the most malarious regions in Sri Lanka. In this study a special focus is to relate soil moisture data obtained from satellite images to malaria incidence in epidemic outbreaks to see if soil moisture data could serve as a tool in a malaria epidemic forecasting system.

Huruluwewa Area

Since 1994 IWMI has been carrying out research in the Huruluwewa area in close collaboration with the Anit Malaria Campaign (AMC), the University of Peradeniya and the Mahaweli Authority of Sri Lanka. Between 1994 and 1998 several studies were conducted to increase the knowledge of malariology in the context of a traditional Sri Lankan dry zone environment with extensive irrigated agriculture, and to assess the feasibility of new control interventions. An insight was gained in anopheline larval ecology, transmission dynamics, the economic burden of malaria to households and the knowledge, practices and attitudes regarding malaria. The work focused on the development of water management methods for malaria control. IWMI's future research will test whether management of water flow in Sri Lanka's Yan *Oya* (River) can effectively reduce breeding of the major malaria carrier mosquito in this region. This work will identify water management scenarios that regulate water depth to decrease the mosquitoes' possibilities to breed. An important factor in this project is to ensure that new water management techniques are integrated into current irrigation practices.

4. PRESENTATIONS

Malaria Pattern in Embilipitiya DSD

Mr. N.B. Munasingha, RMO Embilipitiya

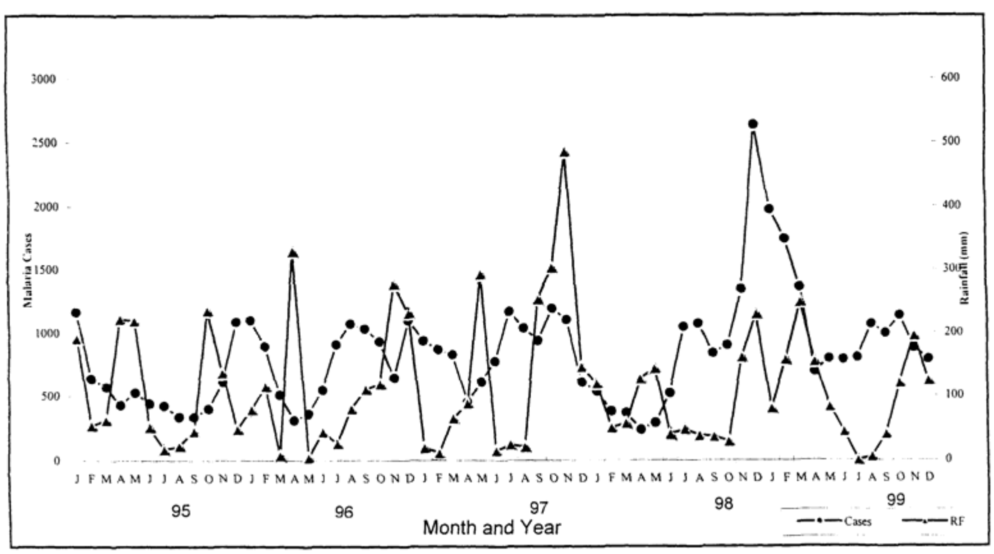
In the Ratnapura District there are 3 MOH divisions with a high number of malaria cases: Balangoda, Opanayaka and Embilipitiya. The yearly number of cases in these divisions is around 2000-3000 a year while in the rest of the divisions this is range from 0 to 300. In the period 1995-1999 there was an increase in the number of cases in these three divisions (see table below).

MOH Division	# positives 1995	# positives 1996	# positives 1997	# positives 1998	# positives 1999
Embilipitiya	1150	1167	2414	3201	3879
Balangoda	2818	5683	2884	2012	3064
Opanayaka	699	240	2836	1565	1708

The AMC has classified malaria risk in three categories: high risk, moderate risk and low risk according to the API and the percentage of cases caused by *Plasmodium falciparum* (PF). For the Embilipitiya DSD the distribution of malaria risk is shown in the table below. Embilipitiya has the highest API of the Ratnapura District. The high risk areas are concentrated around the Uda Walawe tank. High risk areas are: Panahaduwa, Uda Walawe and Thimbolketiya (Mahaweli Special area). The disease pattern in Embilipitiya closely follows the national pattern.

	High Risk	Moderate Risk	Low Risk
Number of GNs	3	27	10
API	>100	50-100	<50
PF	> 30%	20-30%	<20%

There seems to be a correlation between the malaria cases in the Embilipitiya area and the rainfall pattern. Peaks in cases often occur after peaks of rainfall (see figure).

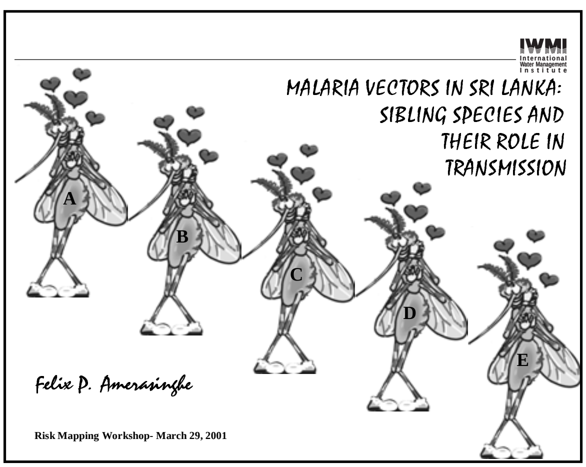


Malaria Vectors in Sri Lanka: Sibling Species and Their Role in Transmission

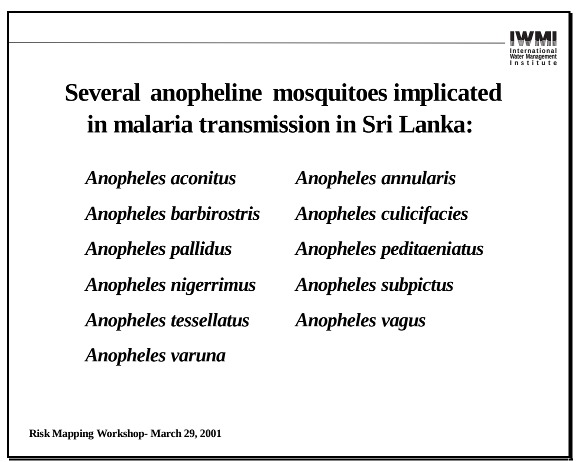
Dr. Felix P. Amerasinghe, IWMI

Several species of anopheline mosquitoes have been implicated in malaria transmission in Sri Lanka. These include *Anopheles aconitus, An. annularis, An. barbirostris, An. culicifacies, An. pallidus, An. peditaeniatus, An. nigerrimus, An. subpictus, An. tessellatus An. vagus*, and *An. varuna*. Of these species, *An. culicifacies* is regarded as the primary vector in the country. *Anopheles subpictus* is generally regarded as the next most important species, with *An. annularis* and *An. vagus* as species that also seem to be locally important at times. Chromosomally distinct sibling species have been recognized in several of these morphospecies. *An. culicifacies* consists of 5 siblings (A, B, C, D and E). Siblings B and E have been recognized in Sri Lanka, and based on evidence from south India, it is now considered that sibling E is the major vector while sibling B is a poor vector. Nothing is known of the ecology and behavior of the newly recognized sibling E, and this is an area that needs immediate investigation. Two sibling species (A, B) have been recognized in Indian populations of *An. annularis*: the status of this species in Sri Lanka is unknown. Four sibling species (A, B, C, D) of *An. subpictus* have been identified in India and Sri Lanka, with sibling B a brackish water breeding species whose adults are extremely susceptible to insecticides. One unpublished study on the ecology of these siblings species has been carried out in Sri Lanka, during which evidence for malaria parasite carriage was obtained from field caught females of sibling C. *An. barbirostris* also consists of 2 sibling species but the status of populations in south Asia in unknown. Among other Sri Lankan anophelines, *An. maculatus* is known to consist of a complex of 9 sibling species. The status of the population in Sri Lanka is unknown, but the species is not regarded as a malaria vector in Sri Lanka.

Powerpoint slides of the presentation:



Slide 1



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Slide 3 - see figure 1

Sri Lanka

All evidence points to the major vector being *Anopheles 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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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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Slide 5

Sibling species can be detected on the basis of:

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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 Disttrict (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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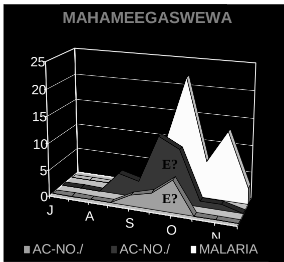
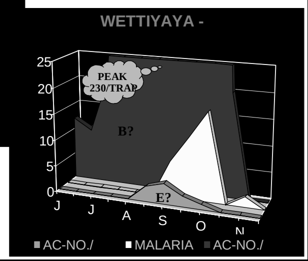


Two riverine villages - different transmission patterns



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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: 3% A, 74% B, 19% C, 4% D (n = 1692)

Inland site: 17% A, 3% B , 73% C, 7% D (n = 165)

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Anopheles subpictus (cont.)

Cattle-baited net traps:
Coastal site: 1% A 92% B 5% C 2% D (n = 1282) Inland site:9% A 9% B 69% C 13% D (n = 55)

Cattle-baited huts:

Coastal site:	**10% A**	**18% B**	**63% C**	**9% D**	**(n = 410)**
Inland site:	**21% A**	**0% B**	**75% C**	**4% D**	**(n = 110)**

Indoor hand-aspirator collections:

Coastal site:	**13% A**	**39% B**	**45% C**	**3% D**	**(n = 75)**
Inland site:	**13% A**	**2% B**	**80% C**	**4% D**	**(n = 46)**

Sibling C: MP sporozoite ELISA-positive

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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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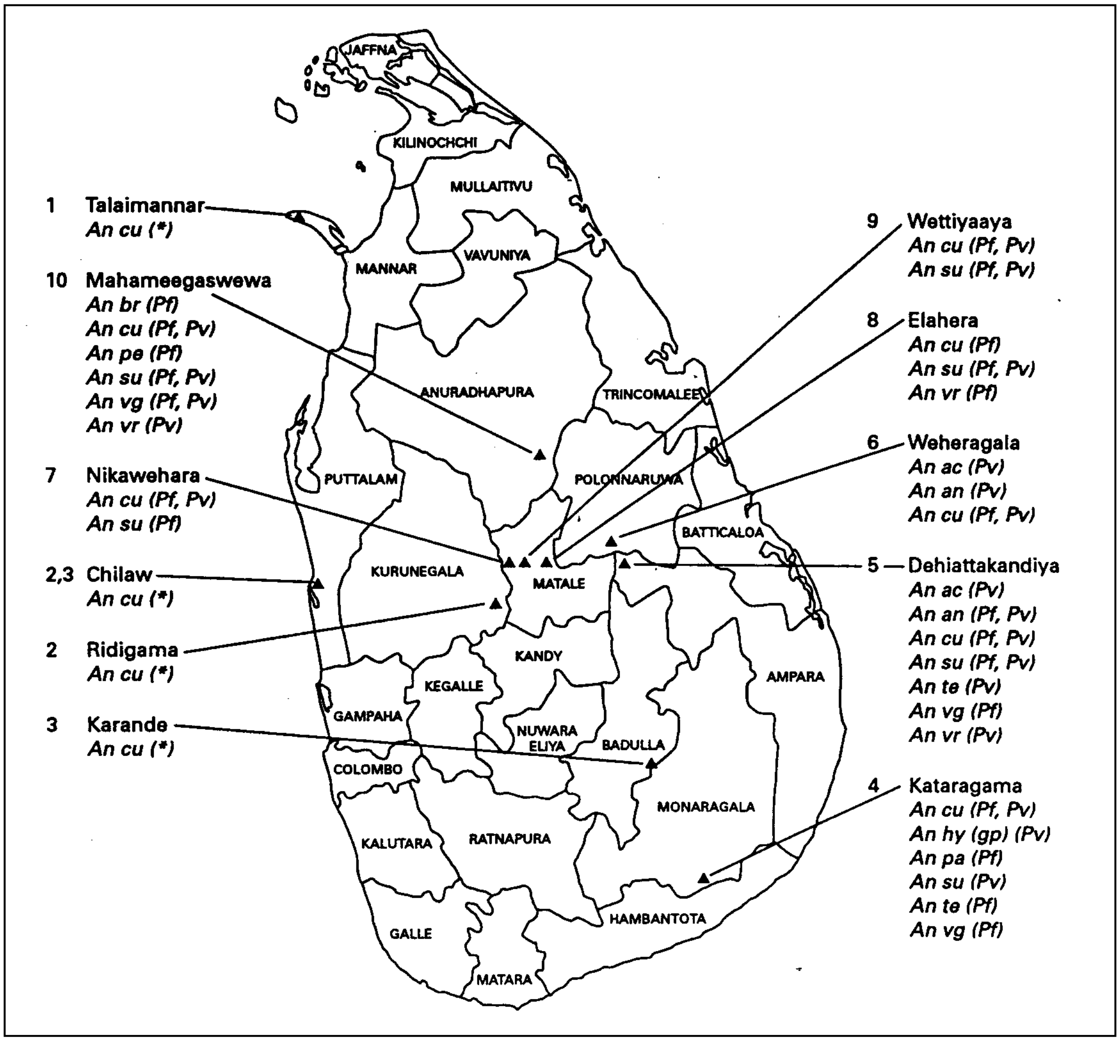
Figure 1. Sites of vector incrimination studies in Sri Lanka and species found. Reproduced after Konradsen et al., 2000.



IWMI Research in Southern Sri Lanka

Dr. Wim van der Hoek, IWMI

IWMI has worked in southern Sri Lanka since the mid 1980s. Most of the work was done in Kirindi Oya on a variety of irrigation performance, operational, and institutional issues, in collaboration with the Irrigation Department and the Department of Agriculture. In Uda Walawe similar studies analyzed the performance of the irrigation system in relation to organizational and institutional factors. Walawe was also one of the cases studies in a multi-country study on 'Irrigation Management for Crop Diversification in Rice-based Systems.' This work was finalized around 1993 but in 1997 there was a request from the Mahaweli Authority to assist in studies to conserve water and increase productivity. Some of the options are further crop diversification, drip irrigation for bananas, and the alternate wet and dry irrigation method of cultivating rice.

Changes in agricultural water management have important effects on the breeding of mosquito vectors of human disease, the need for agrochemical applications, and the availability of drinking water. There are, therefore, important human health implications of such changes in agricultural water management. One of the projects that are now being implemented by IWMI and its collaborating institutions is to integrate the priority public health issues in overall water management in the Uda Walawe river basin. This is a novel approach that will improve the understanding of causal linkages between water, agriculture, the environment and human health in agro-ecosystems, not only in the Uda Walawe basin but also in other intensive irrigation projects.

The hypothesis of the present research is that the operation of irrigation systems can be changed so as to achieve positive health impacts, with minimum impact on agricultural performance. More specifically it is hypothesized that the breeding of the mosquito vectors of human disease, the need for agrochemical inputs, and the availability of drinking water are directly influenced by changes in irrigation water management

One of the activities of the project is to use new technologies such as geographical information systems (GIS), global positioning system (GPS), and remotely sensed satellite imagery to map the availability of surface water, vegetation, land use patterns, and other factors important for malaria transmission. IWMI and the AMC are using the larger Uda Walawe area as a first location to develop a risk map for malaria. Once this has been tested and validated, it could be extended to other areas and even to the entire island. Such a risk map will make it possible to target priority areas with control activities. It can also be useful as a decision support tool in health impact assessments for water resources development projects, and as part of an early warning system for impending epidemics.

Powerpoint slides of the presentation:

IWMI involvement in Uda Walawe

- 1986-1993: Research on improvements in water management and crop diversification
- 1997: Request from MASL to assist in studies to conserve water and increase productivity

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Slide 1

Human health study

- Increase the productivity of water while reducing human health risks
- Develop a methodology for an integrated approach to agricultural water management in river basins
- Evaluate the impact of different water management regimes on:
  - vector mosquito breeding
  - availability of water for domestic use
  - need for agrochemicals

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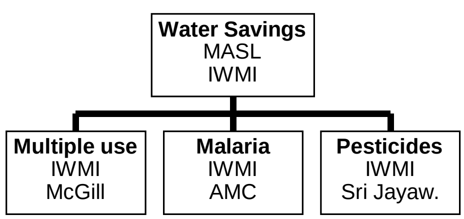
Project Outline



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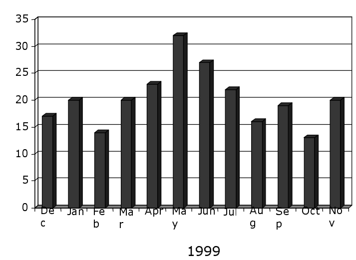
Admissions for pesticide poisoning in Embilipitiya Base Hospital



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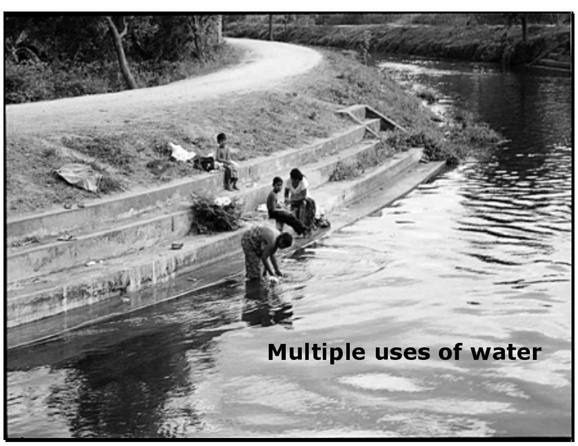

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Drinking Water Sources

	Fecal contam.	F, salt, iron
Surface water	++	-
Deep wells	-	++
Shallow wells	±	±

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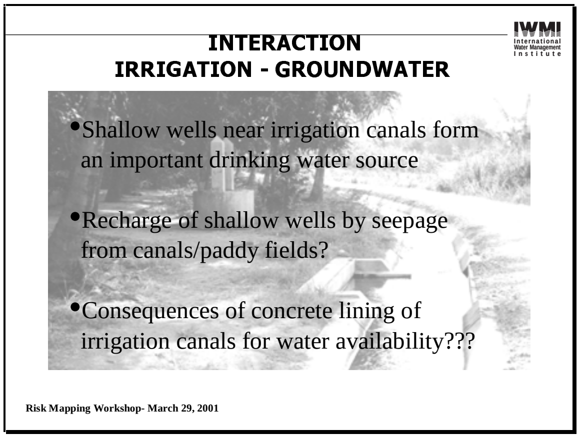

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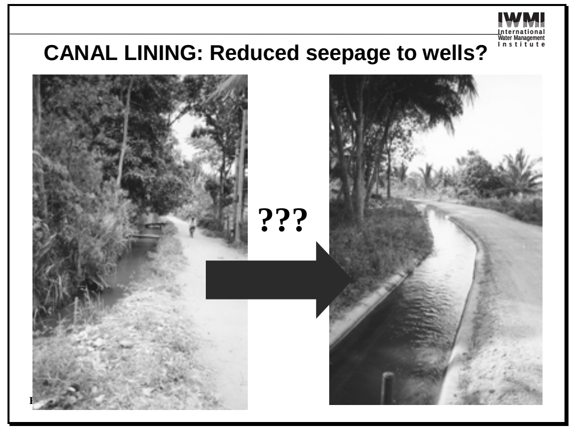

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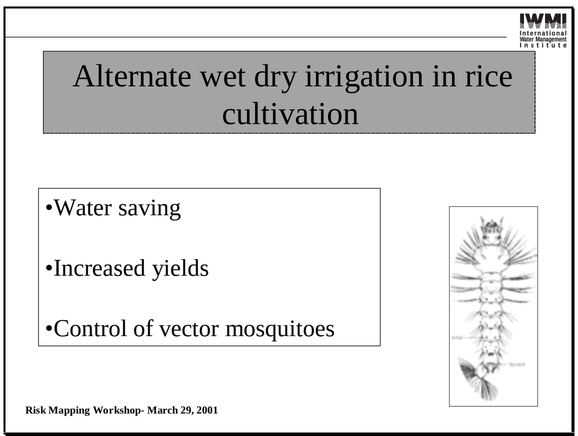

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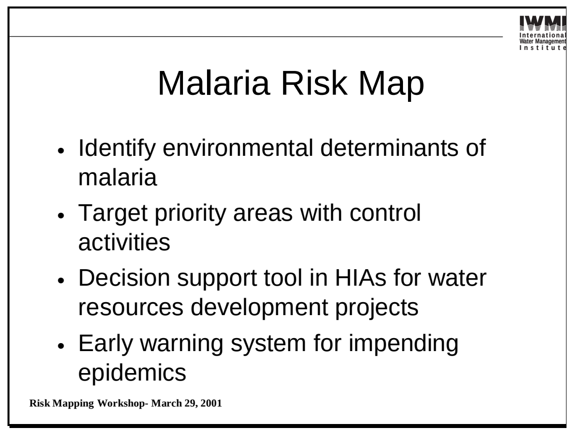

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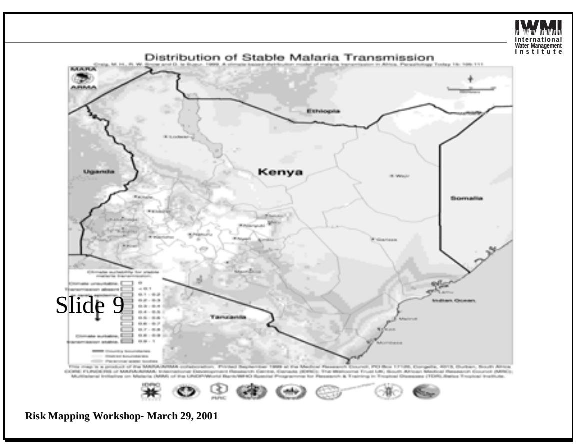

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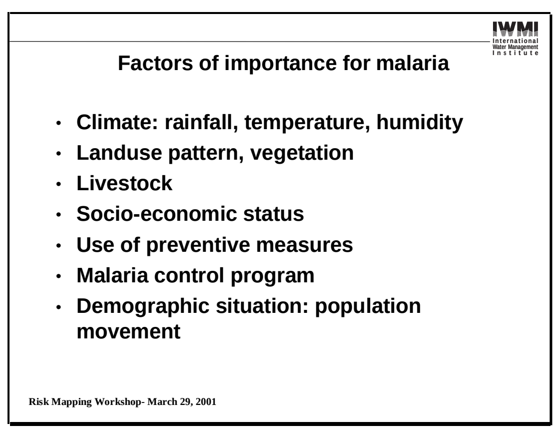

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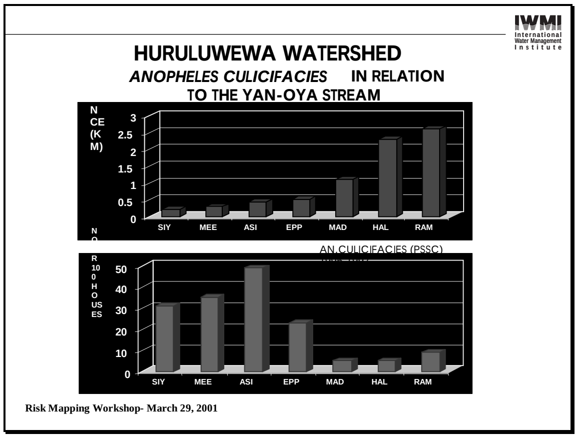

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Huruluwewa: 7 villages

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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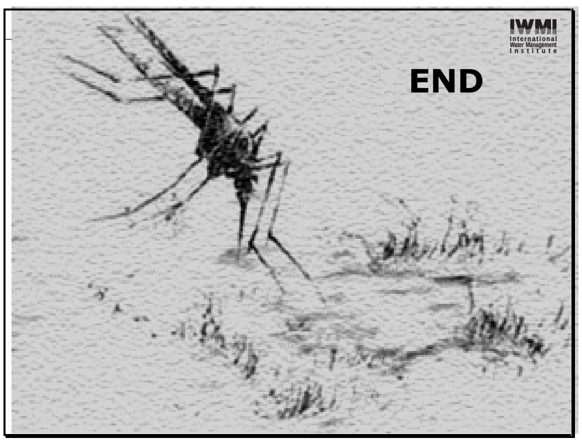

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Surveillance and Spatial Targeting of Malaria Control

D. M. Gunawardena and Lal Mutuwatta, IWMI

What is surveillance?

Surveillance "is the ongoing systematic collection, analysis, and interpretation of health data essential to the planning, implementation and evaluation of public health practices, closely integrated with the timely dissemination of these data to those who need to know. The final link in the surveillance chain is the application of these data to prevention and control (CDC)." Simply, surveillance is "data collection for action." In the surveillance mechanism it is important to have the data collected in a regular, frequent and timely manner, and orderly consolidation, evaluation and descriptive interpretation of data with prompt dissemination of findings.

Surveillance mechanisms of malaria control in Sri Lanka.

The national malaria control program in Sri Lanka has an elaborated surveillance system, which was originally established during the eradication era. This mainly consists of:

1. Epidemiological surveillance- Case data (Blood smears/ Pv/ Pf/ Sex/Age groups
2. Entomological surveillance- Vector data (Density, Biting rate/EIR/Resistance status)

The workshop on malaria surveillance held at the Family Health Bureau, Colombo 22-24 September 1999 for all regional malaria officers addresses the following matters:

Major issues discussed:

- Lack of staff for routine surveillance (Surveillance agents and diagnostic facilities)
- Slow flow of surveillance data (more than one month)
- Invalid malariometric index calculation (API and FR)
- Data not being optimally used for planning purposes (especially entomological data)
- Lack of feedback on surveillance data (Monthly reports or annual reports?)

Other issues discussed:

- Geographic unit (Village/GN)
- Frequency of reporting (Weekly/Monthly)
- Unequal distribution of surveillance (most of the facility available at town level)
- Availability of other relevant data (demographic data/housing/climate/land use)
- Additional data (treatment failure/severe and complicated cases/deaths/prophylaxis etc)
- Private sector case data (over 50% of malaria patients are reported from the private sector)
- Data collection format (deficiencies), new format necessary?

GIS and spatial targeting

The availability of advanced spatial analytical technologies such as Geographical Information Systems (GIS) and Remote Sensing are powerful tools that could be used in the decision making process in malaria control. This technology will enable the study of the spatial and temporal distribution of malaria and its relationship with other parameters of malaria transmission. Simply, mapping functions of GIS could be used to identify and highlight risk areas and risk factors. In planning and implementing control activities this will assist in spatial targeting of control measures and in resource allocation. In monitoring and evaluation this will help identify where the control measures have not been successful.

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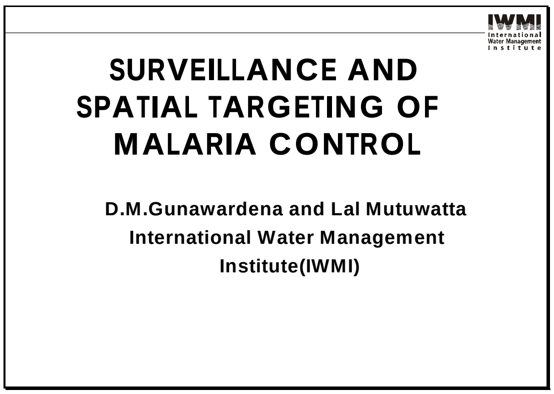

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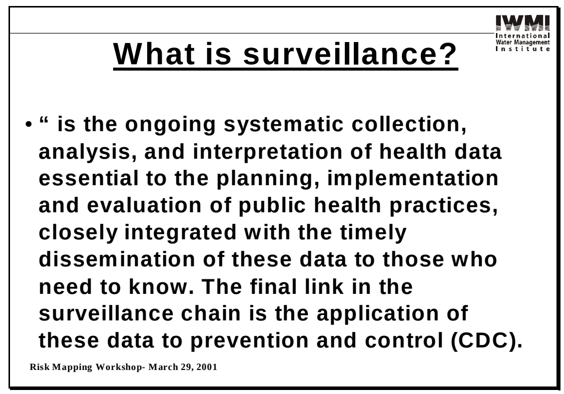

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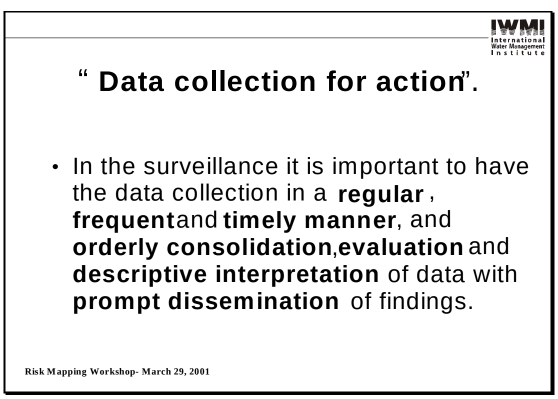

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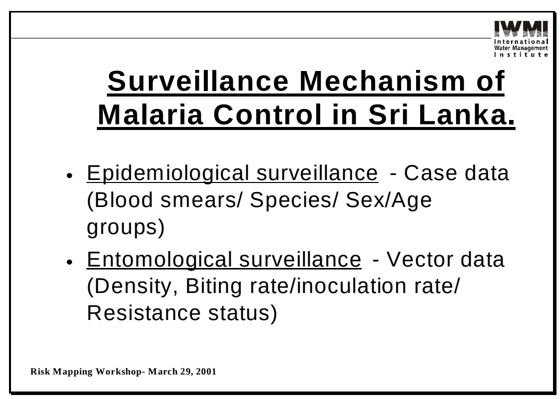

Slide 4

Matters discussed at the workshop on malaria surveillance (FHB, Colombo 22-24 Sep 1999).

Major issues

1. Lack of staff for routine surveillance (Surveillance agents/diagnostic facilities)
2. Slow flow of Surveillance data (more than one month)
3. Invalid malariometric indices calculation (API / % FR)
4. Data not being optimally used for planning purposes (especially entomological information).
5. Lack of feedback on surveillance data (Monthly report/annual report?)

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Slide 5

Other issues discussed

- Geographic Unit (Village/GN)
- Frequency of reporting (Weekly/Monthly)
- Unequal distribution of surveillance (most of the facility available at town level)
- Availability of other relevant data (demographic data/housing/climate/land use)
- Additional data (treatment failure/severe & complicated cases/deaths/prophylaxis etc)
- Private sector case data (over 50% of malaria patient from private sector)
- Data collection format (deficiencies) new?

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Slide 6

Spatial analysis of malaria risk 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.
- Delay the emergence of resistance.

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Slide 7

Use of advance spatial analytical technologies in spatial targeting

- GIS (Geographical Information System)
- RS (Remote Sensing)

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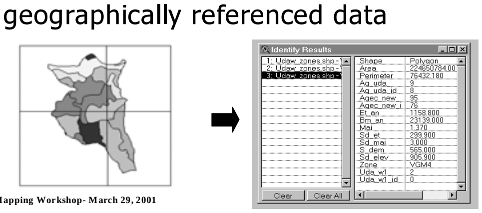
Slide 8

What is GIS?

A computer assisted information management system of geographically referenced data



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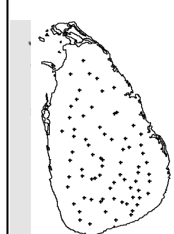
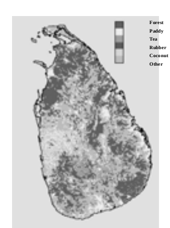
Slide 9

Annual precipitation (mm) June 1999 to May 2000



Major Land Use types in Sri Lanka



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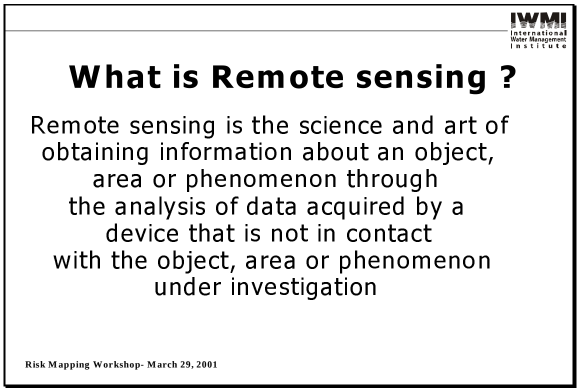
Slide 10



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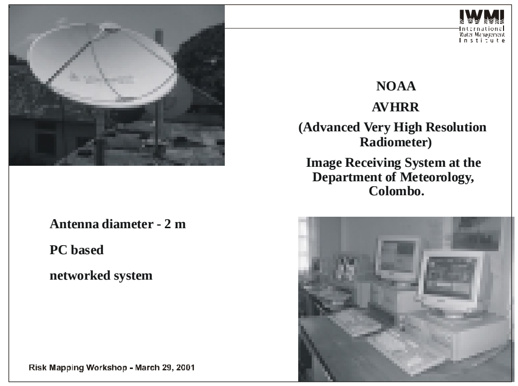

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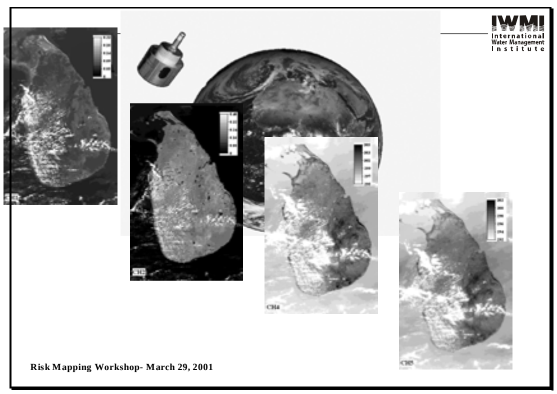

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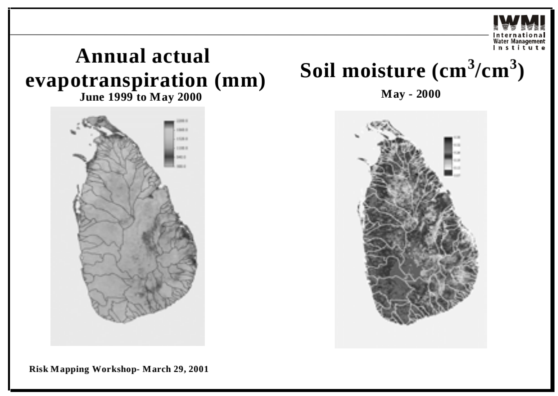

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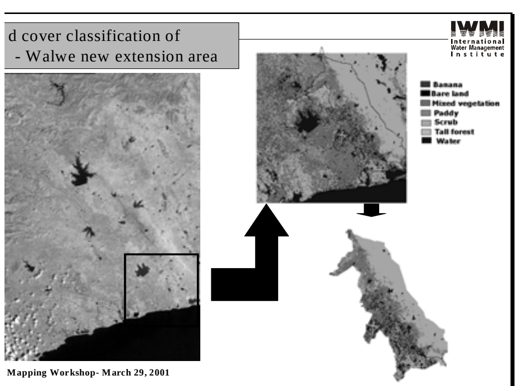


Slide 15

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

Eveline Klinkenberg, IWMI

Six Divisional Secretary Divisions (DSDs) from the Uda Walawe regions were selected: Embilipitiya, Thanamalvilla, Sevenagala, Angunukolapelessa, Ambalantota and Sooriyawewa. All confirmed malaria cases reported to the government health facilities within these 6 DSDs (see Figure 2) were collected for the period January 1991-August 2000. Additionally, data was collected from health facilities just outside the 6 DSDs to which the people from inside the 6 DSDs would go. Malaria data from private clinics were not available and therefore could not be included. As population data were in general only available per Grama Niladari area (GN), all data were up-scaled to GN level. For each GN the malaria incidence (number of cases per 1000 inhabitants) was calculated for each month for the period January 1991-August 2000. These malaria incidences were mapped using GIS software (ARCVIEW) (see Figure 3).

The malaria incidence pattern showed:

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

A second step, which is still ongoing, is to correlate the found malaria incidence pattern to possible explaining factors. For this purpose, data for the following parameters have been collected so far: land use, presence of water bodies (rivers, streams, tanks), rainfall, socio-economic data (% of families receiving Janasaviya or food stamps, electricity supply, land and house ownership), control measures (spraying, use of bed-nets) and soil moisture data (from satellite images). Some parameters (land use, rainfall) are being processed with the aid of GIS software (ARCVIEW, ARCINFO) to obtain a value for each GN. The additional data needed are house construction data and entomological data as only limited data are available.

In general, it could be expected that in the irrigated areas malaria incidence is higher due to the almost continuous presence of water for mosquito breeding and that in the non-irrigated areas malaria is restricted to the rainy season this is not the case in the Uda Walawe region. Preliminary results reveal that there is a clear link between malaria incidence and land use. Malaria incidence is higher in the *chena* (slash and burn cultivation) areas and lower in the paddy and other crop and plantation areas. This could be related to the socio-economic status for which statistical analysis is ongoing or it could be related to the presence of additional breeding sources for mosquitoes in the *chena* areas. In the Uda Walawe area *chena* cultivation is most dominant in the Thanamalvilla DSD. Comparing the presence of water bodies in the high and low incidence areas revealed that the high risk area of Thanamalvilla contains a large number of abandoned tanks, while the rest of the area, with generally lower incidence contains several maintained tanks, but hardly any abandoned tanks. Therefore, it could be possible that these abandoned tanks form an important source of mosquito breeding, as they are not maintained. The importance of the abandoned tanks was investigated during a fieldtrip on the 28th of March 2001 the findings of which are summarized in chapter 7.

Figure 2. Location of hospitals in the Uda Walawe area from which data were collected to calculate the malaria incidence.

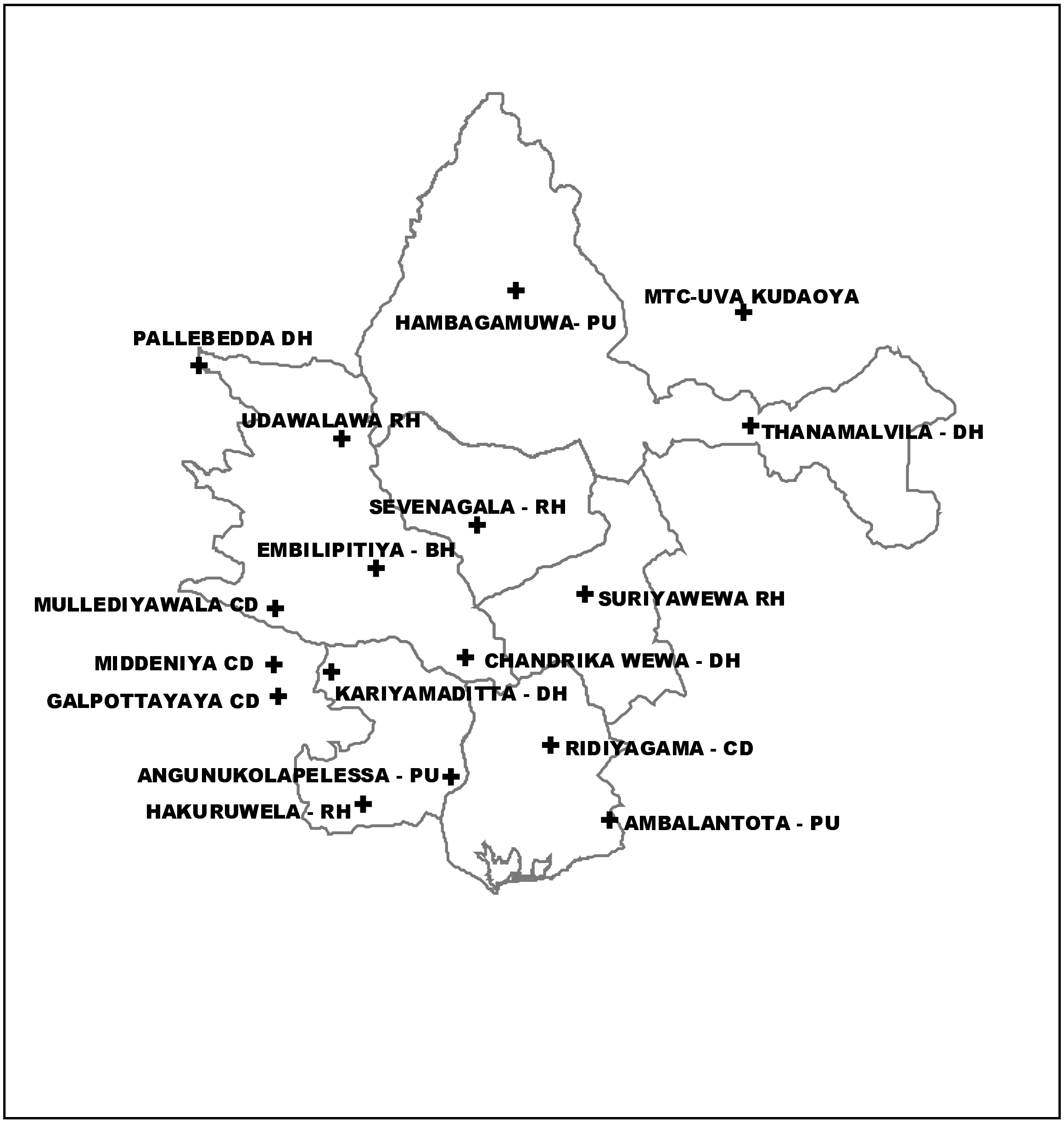
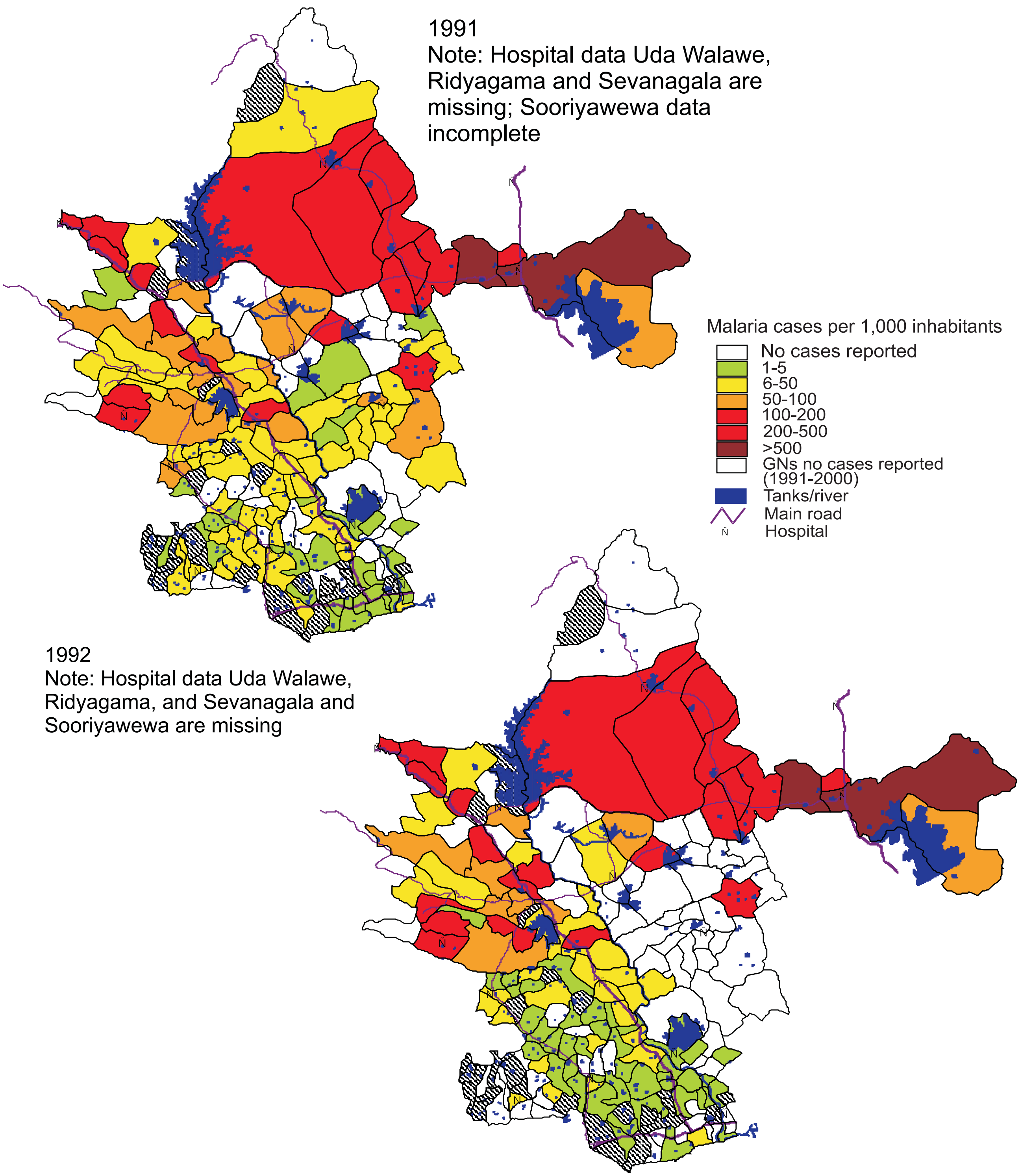
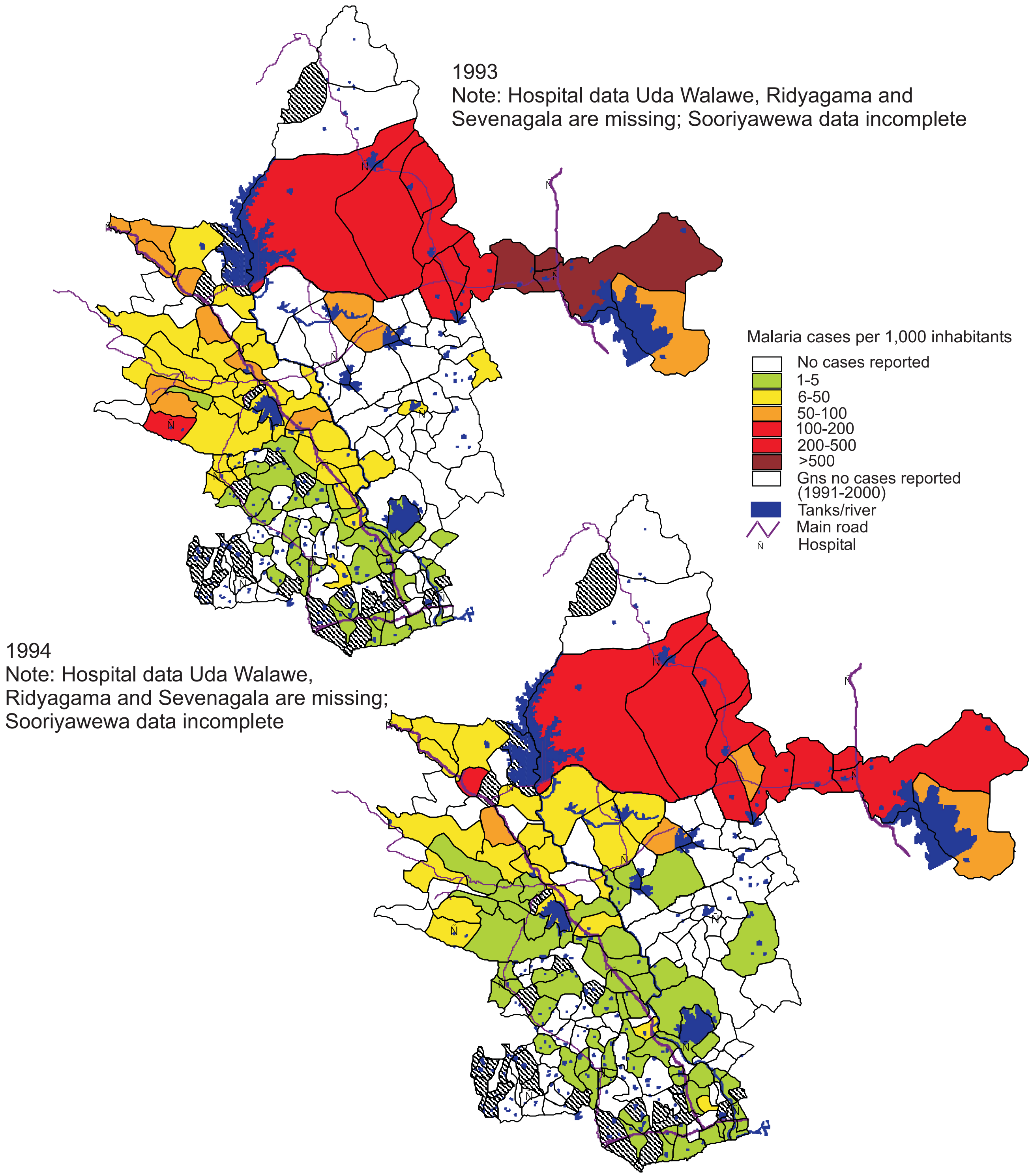
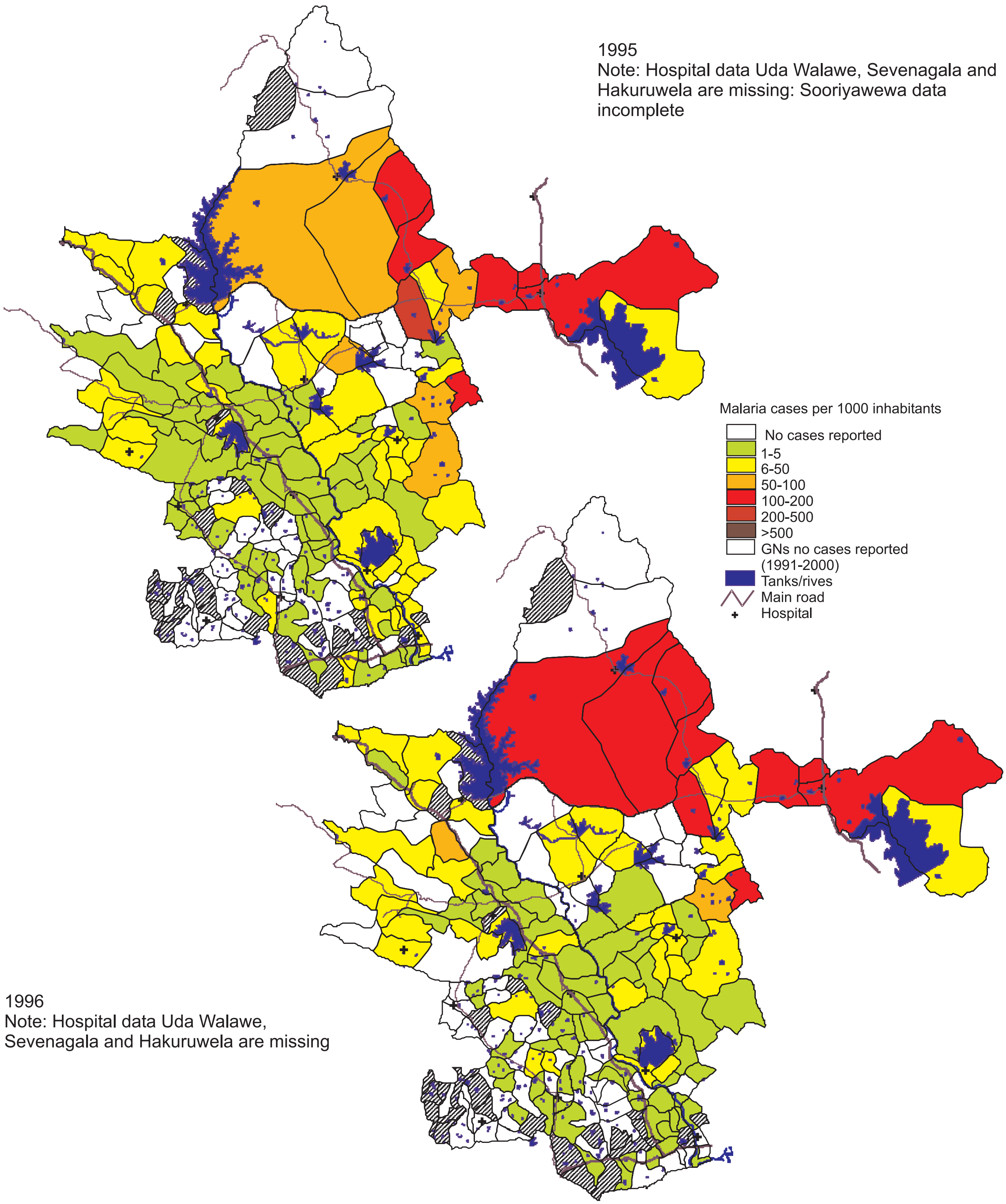


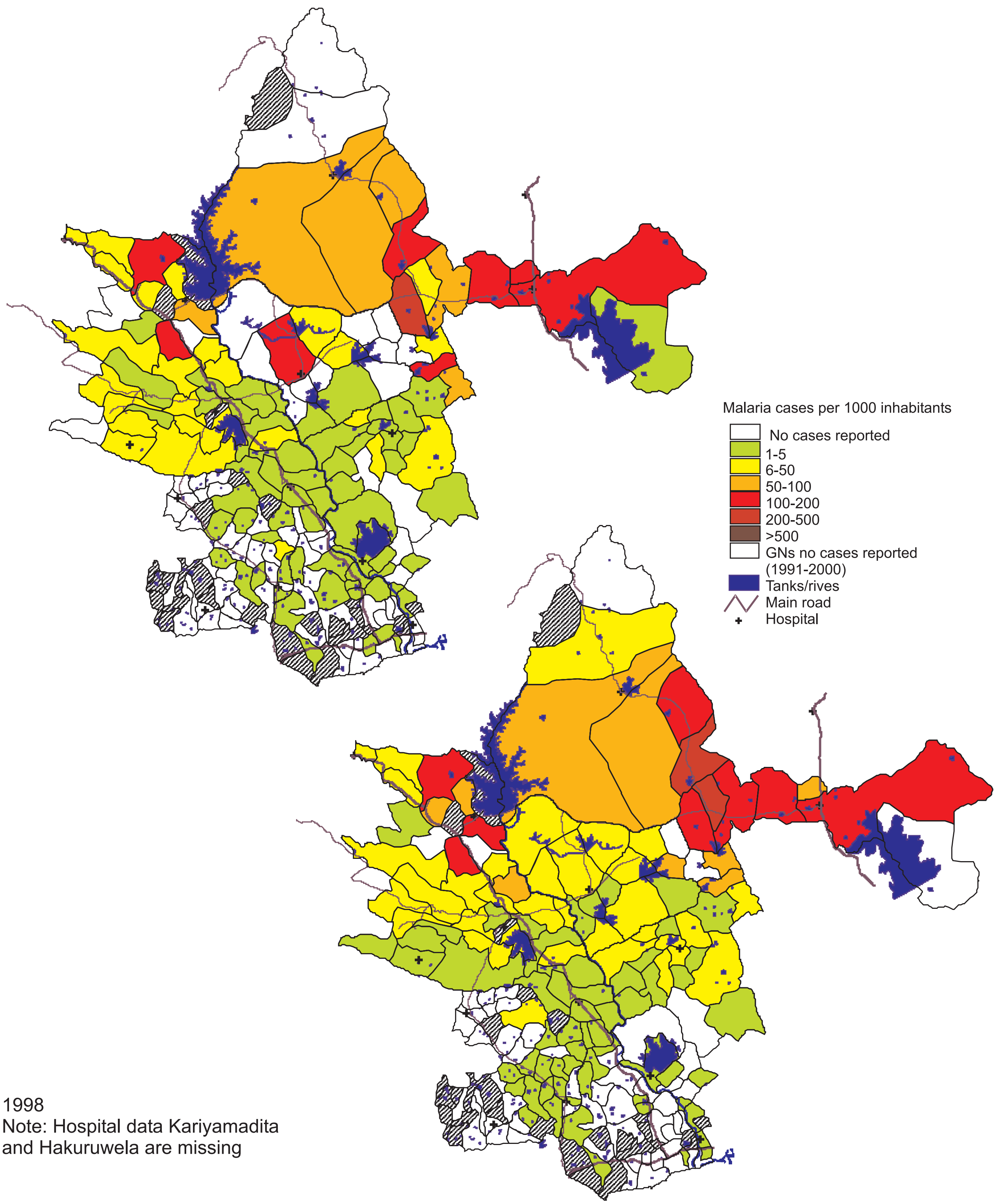
Figure 3. Malaria incidence maps for the Uda Walawe area for the period 1991-2000.



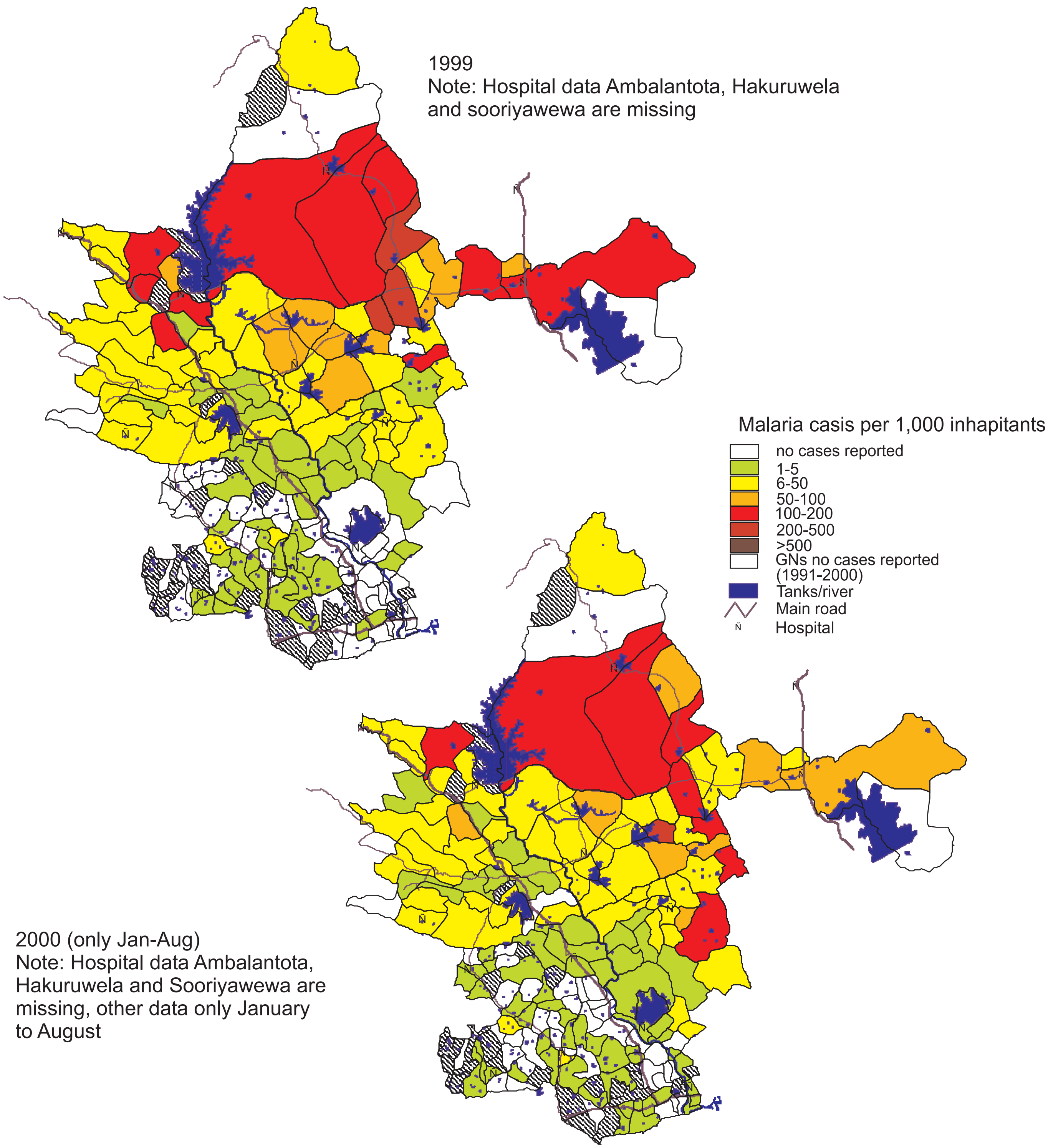

1993
Note: Hospital data Uda Walawe, Ridyagama and Sevenagala are missing; Sooriyawewa data incomplete
Malaria cases per 1,000 inhabitants
No cases reported
1-5
6-50
50-100
100-200
200-500
>500
Gns no cases reported (1991-2000)
Tanks/river
Main road
Hospital
1994
Note: Hospital data Uda Walawe, Ridyagama and Sevenagala are missing; Sooriyawewa data incomplete


1995
Note: Hospital data Uda Walawe, Sevenagala and Hakuruwela are missing: Sooriyawewa data incomplete
Malaria cases per 1000 inhabitants
No cases reported
1-5
6-50
50-100
100-200
200-500
>500
GNs no cases reported (1991-2000)
Tanks/rives
Main road
Hospital
1996
Note: Hospital data Uda Walawe, Sevenagala and Hakuruwela are missing

1997
Note: Hospital data Kariyamadita and Hakuruwela are missing



1998
Note: Hospital data Kariyamadita and Hakuruwela are missing


1999
Note: Hospital data Ambalantota, Hakuruwela
and sooriyawewa are missing
Malaria casis per 1,000 inhapitants
no cases reported
1-5
6-50
50-100
100-200
200-500
>500
GNs no cases reported
(1991-2000)
Tanks/river
Main road
Hospital
2000 (only Jan-Aug)
Note: Hospital data Ambalantota,
Hakuruwela and Sooriyawewa are
missing, other data only January
to August

Powerpoint slides of presentation:

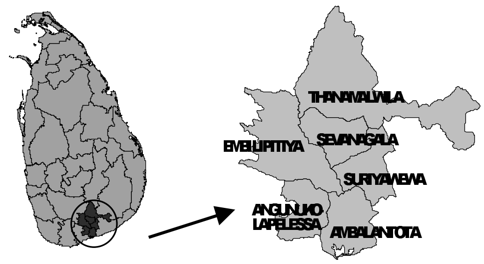
Towards a risk map of southern Sri Lanka

Results of Uda Walawe region

Eveline Klinkenberg, IWMI

Slide 1

Project area



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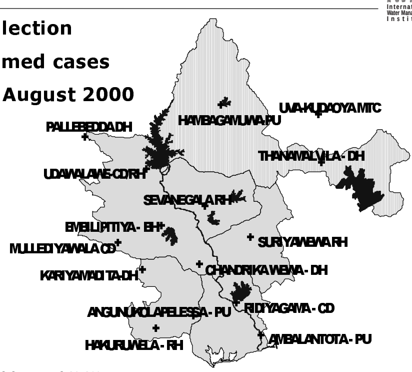
Slide 2

Data Collection

*** confirmed cases**

*** 1991- August 2000**



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Slide 3

STEP 1: Data Collection

*** malaria cases village wise 1991- Aug. 2000**

*** population 1991-2000 (available at GN level)**

*** maps with roads, streams, GN boundaries**

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Slide 4

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**

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Slide 5

Malaria per GN
Uda Walawe area 1991-2000

No cases reported	100-200 cases
1- 5 cases	200-500 cases
6-50 cases	>500 cases
50-100 cases	No cases ('91-'00)

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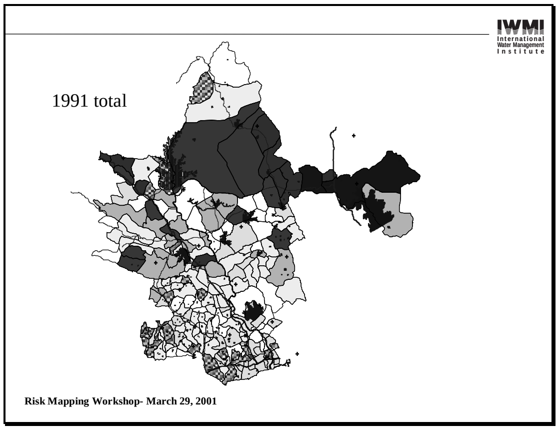
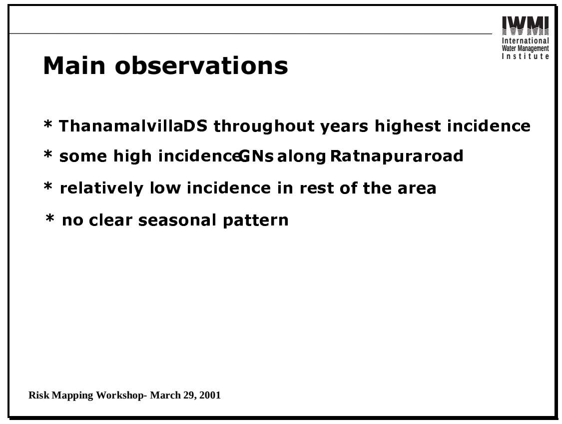
Slide 6



Slides 7 16: Total yearly malaria incidence data 1991-2000, see figure 3.



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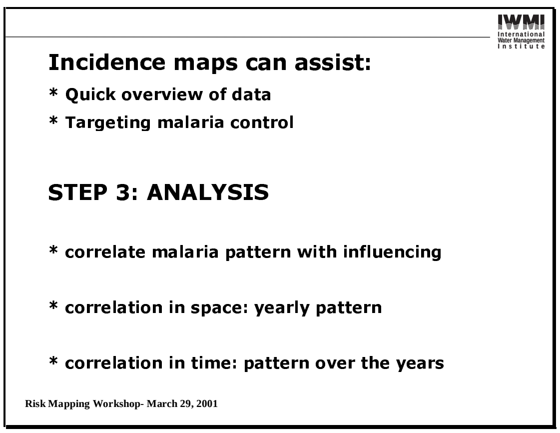

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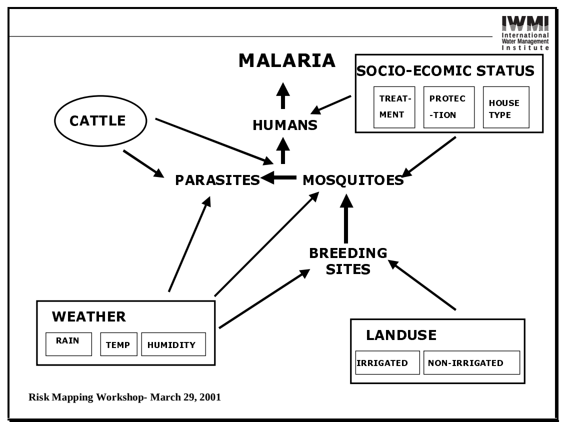

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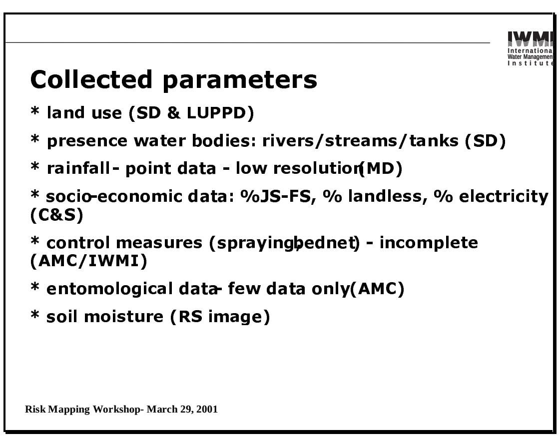

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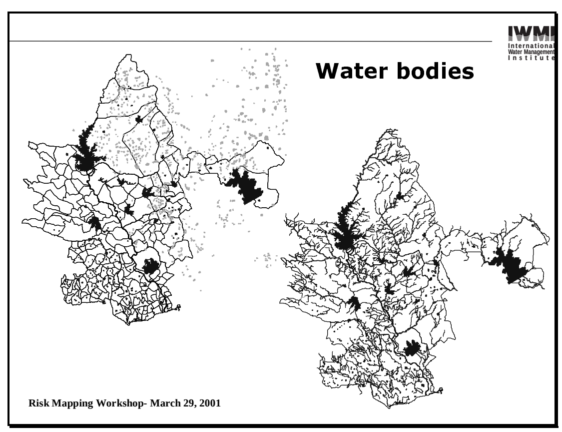
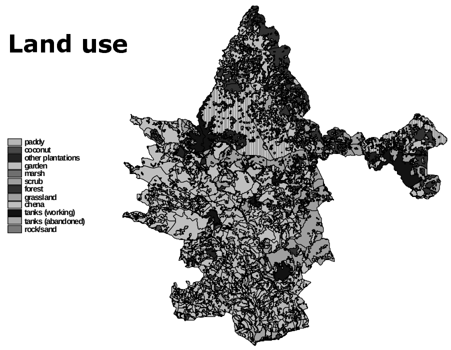


Slide 21

Land use



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Slide 22

Problems data collection/restriction data set

*** most parameters only available for one year**

*** data often not available at GN level**

*** part people go to private hospitals**
--> underestimate cases

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Slide 23

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**
*** more data over time**
*** malaria data September-December 2000**

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Slide 24

Riskfactors (preliminary)

*** chena/non agricultural area high malaria incidence**
*** irrigated areas relatively low incidence**

Would expect irrigated area more water
--> more mosquitoes?!
Reasons?!

? socio-economic: housing, income, general susceptibility
? chena area different sources of mosquito breeding

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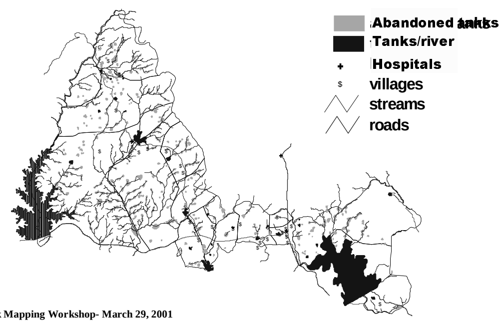
Slide 25

FOCUS on area with HIGH incidence Thanamalvillaarea



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Slide 26

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 relatively dry, malaria confined to rainy season BUT no clear seasonal pattern visible

Abandoned Tanks possible breeding source??

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Slide 27


Thanks to Mr. N.A.S.BNissanka

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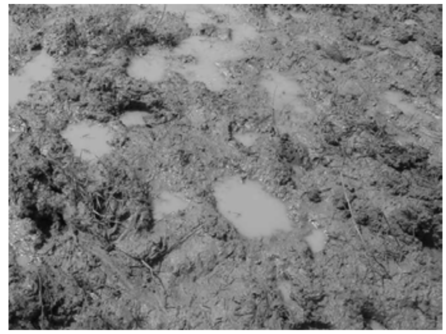
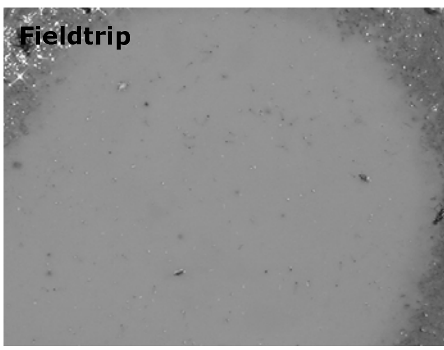
Slide 22



Risk Mapping Workshop- March 29, 2001 Thanks to Mr. N.A.S.BNissanka

Slide 22

Fieldtrip



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Slide 22

Preliminary results

* correlation malaria incidence - landuse

* higher incidence in chena /non agricultural areas

* lower incidence in paddy/OFC area

* possible relation with socio-economic status

* in Thanamalvilla area abandoned tanks additional mosquito breeding source??

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Slide 22

Next step

* define main source of breeding inThanamalvilla area/where cases come from (cooperation with AMC/health staff)

* finish statistical analysis

* continue collection additional data

* collect additional entomological data

* define risk factors (if present)

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Slide 22

Group Assignment

5 groups, discuss:

1. Is it possible to identify high risk area for malaria in the Division

2. If yes, which parts are high risk areas. Please indicate on map provided.

3. Are there known environmental risk factors in the Division, I.e. certain surface water sources, vegetation and cultivation patterns, gem mining etc.

4. If so, where are they located?

5. Could risk mapping play a role in planning of malaria control activities in the Division? Explain how.

Give short presentation of 10 minutes (+ 5 min.

Start presentation 15.15 hours!

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Slide 22

5. SUMMARY OF PRESENTATIONS

The groups addressed the following questions:

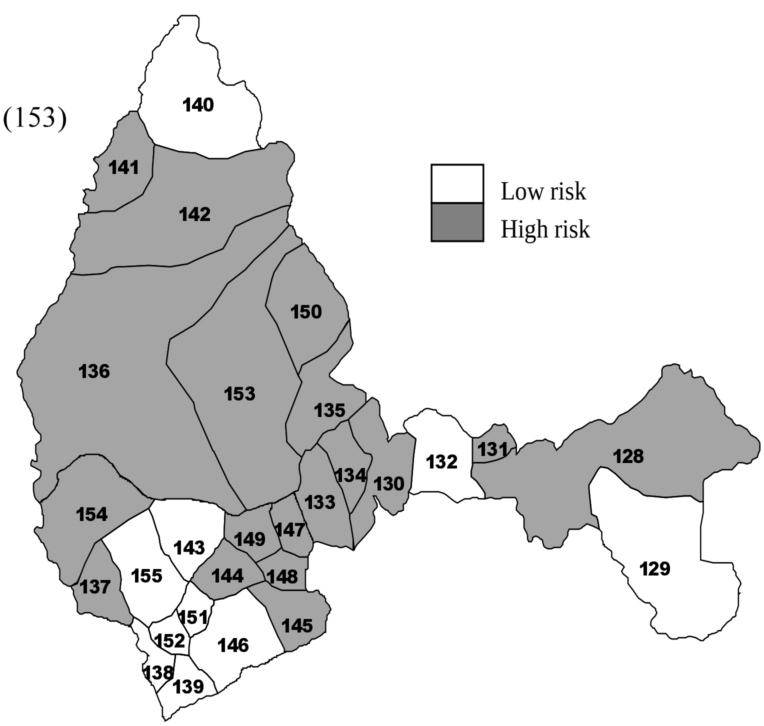
1. Is it possible to identify high risk areas for malaria in the Division?
2. If yes, which are the high risk areas? [Please indicate on map provided.]
3. Are there known environmental risk factors in the Division, i.e. certain surface water sources, vegetation and cultivation patterns, gem mining, etc. Where are they located?
4. Could risk mapping play a role in planning of malaria control activities in the Division? Explain how.

Presentation: Thanamalvilla-Sevenagala DSD
By Mr. H. M. Faizal, RMO Moneragala District

High risk areas:

There are 27 GN areas in these two DSDs of which 16 are high risk areas. This information was based on the personal knowledge of the participants present. The high risk GNs were:

- Hambagamuwa (136)
- Aluthwewa (142)
- Hambagamuwa Colony (J.P.) (153)
- Kahukurullan Pelessa (150)
- Kotavehera manakada (141)
- Mahawewa (135)
- Kivulara (131)
- Suriara (133)
- Weliara (147)
- Habaraluwewa (143)
- Samagaipura (149)
- Nugegalayaya (145)
- Thanamalvilla (128)
- Katupilagama (154)
- Kiriibanwewa (144)
- Punchiwewa (148)



The response to the question why the three GNs in the Thanamalvilla DSD were classified as low risk was:

- Kandiyapitawewa (140) belonged to the Balangoda area and since it was mountainous and forested there were less cases in that area.
- Sinukkuwa (129) is an area with few people and few houses and, as such hardly any cases are recorded.
- Bodagama (132) is a town area, and does not have many cases of malaria.

Environmental risk factors for the Thanamalvilla area:

1. A number of slow moving streams provide breeding sites for the vector. Rivers flowing through the area are: Kirindi Oya, Mal Ara, Mau Ara, Mulakandu Ara, Habaraluam
2. Abandoned tanks could serve as breeding sites, as shown in the presentation by Ms. Klinkenberg. However the importance of these abandoned tanks needs to be confirmed with additional entomological surveys.
3. Irrigation canals and channels which are not lined provide breeding sites.
4. *Chena* (slash and burn) cultivation: mostly illegal, e.g. ganja (cannabis) cultivation. This cultivation takes place deep in the jungle and these areas cannot be easily accessed because of animal and gun traps. Most *chena* cultivators are migrants who live in the border areas of Hambantota and Embilipitiya. As such, people movement also has a bearing on the number of malaria cases reported.
5. Poor socio-economic status of the people in the area. Farmers' incomes are not very high and house construction is, in general, very poor.
6. Long planned irrigation projects. Some projects have been planned for four to five years and implementation takes a long time. For instance the Mau Ara project took a long time for development. During the period of construction breeding sites are formed in the channels and areas under construction and therefore the length of time taken for the construction phase poses a malaria risk on the area.

Risk areas:

1. Chena cultivation areas. Chena cultivation takes place in most areas of the Thanamalvilla DSD. The main areas are: Kahukuranpelessa (150), Aluthwewa (142), Hambagamuwa Colony (153), Kotavehera manakada (141), Mahawewa (135), Kivulara (131), Suriara (133), Weliara (147), Nugegalayaya (145), Punchiwewa (148)
2. Abandoned tanks and slow moving streams. These are present throughout the area.
3. Irrigation projects: e.g. Udu Mauara (143), Suriara (133)

Role of risk mapping:

1. The types of breeding sources could be identified and larval control could be scheduled easily and in advance and thereby saving on the resources such as Abate (chemical larviciding).
2. To design and undertake large residual spraying activities in a proper manner since it allows identifying areas from where the vectors come.
3. The establishment of treatment centers and operation of mobile clinics in areas from where cases are reported. Thus introducing control activities in time instead of being late, as often is the case now, when they can only start the control after an outbreak is reported.
4. Since epidemics could be forecasted – be alert and prepared.
5. Mobilize entomological teams to visit the high risk areas.
6. Organize mass blood survey programs
7. Assist in planning of the control programs.
8. Targeting of high risk areas at an early stage.

A question raised by the Thanamalvilla group was "How early could a malaria epidemic be forecasted with risk mapping?"

Dr. Felix Amerasinghe replied that epidemic forecasting and basic risk mapping of cases are two different things that should be clearly distinguished:

1. Basic risk mapping was the mapping of malaria data on a map. This could be done as soon as the malaria case data was available. For each area it takes some time to build the basic data set but once this is done, every month/week a new map could be generated, showing malaria incidence at GN (or at any other requested) level. Reading such maps would allow for control work to be introduced to the areas with high risk and high malaria incidence.

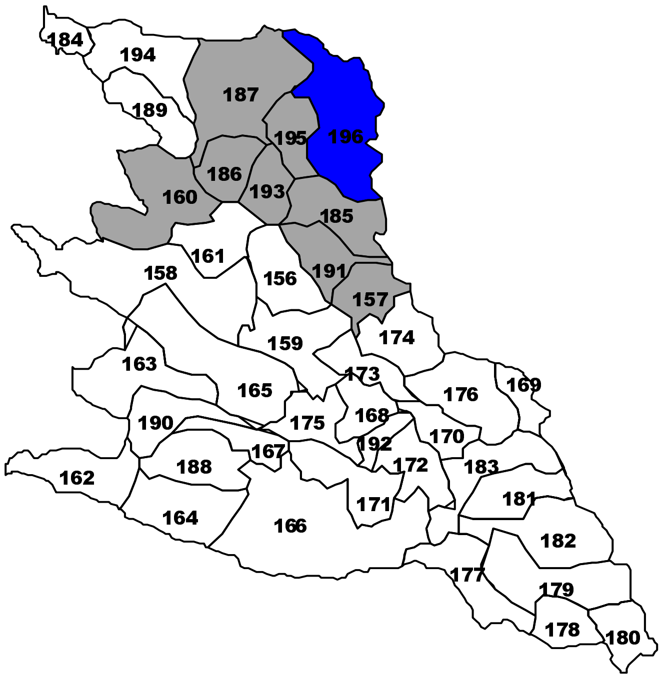
2. Epidemic forecasting was the prediction of impending epidemics. This could only be done if clear indicators were found which would allow for the prediction of areas where and the times when epidemics are prone to arise. This was not the case yet in Sri Lanka. What is being done now is the analysis of the influence that different parameters e.g. land use, rainfall, socio-economic data etc. have on malaria incidence. With this analysis a first step could be taken in the development of a model to predict impending epidemics. The type of risk factors defined and the possibility to extract these risk factors from satellite data would determine how early a prediction could be made.

What could be done after the first analysis of the parameters was to point out high risk factors and high risk areas, which could be used to target malaria control or maybe even monitor certain parameters or occurrences of certain events that are likely to have an impact on malaria incidences.

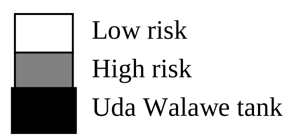
Dr. Gunawardena went on to state that IWMI was currently doing a study in the Moneragala District investigating whether soil moisture data derived from satellite images could be used to predict impending epidemics. This was being done with data from the December 1999- February 2000 epidemic that occurred in the district.

Presentation: Embilipitiya DSD
By Mr. N.B. Munasingha, RMO Embilipitiya

High risk areas:



- Uda Walawe (195)
- Ratkarawara (185)
- Thimbolketiya (193)
- Panahaduwa (187)
- Gangeyaya (157)
- Yaya 2 (191)
- Kolombageara ?? (186)
- Miriswelpotta ?? (160)



Mr. Munasingha opened the presentation by stating that what he was presenting at that time was a summary of the results of the group discussion and that it did not necessarily reflect his personal opinion.

Apart from the areas identified by him that morning (see page 5), the group felt that 3 more GNs should be added as high risk areas. These areas were identified from the personal knowledge of the group. According to the group, apart from the four areas earlier indicated (Uda Walawe, Ratkarawara, Thimbolketiya and Panahaduwa) the GNs of Gange Yaya and Yaya 2 should also be added as high risk areas. Mr. Munasingha himself was not in agreement with the addition of the latter two areas as high risk as there was no data to confirm this. He said that there were problems with the data for that area and he believed that cases were sometimes assigned to the wrong GN.

Two other questionable areas that were indicated as high risk were Colombage Ara and Miriswelpotta. There was a debate within the group as to whether these two were high risk areas or not. Munasingha's personal opinion was that these two should not be indicated as high risk areas, while the group felt that they should be. Therefore, as could be seen from the map of this presentation (see above) there was not much difference from the map that was shown by him in his presentation this morning. It was noted that the high risk areas were closest to the Uda Walawe (tank) region.

Environmental risk factors:

Mr. Munasingha stated that since the question only asked for environmental risk factors, the group concentrated on this aspect and other factors such as socio-economic etc. were not addressed. The environmental risk factors present in the Embilipitiya DS were

The natural water ways (Maha-ara, Malabota-ara, Meegeha-ara)

a. The rainfall pattern (see page 5)
b. People migration
c. Sugarcane cultivation in the Uda Walawe/Sevenagala area.
d. If risk could be related to a crop then it was sugarcane. People go to the Sevenagala area for temporary work during sugarcane harvesting. People get infected with malaria during this period and return with malaria. The sugarcane itself is not the risk factor but during their work related to the sugarcane harvesting people live in temporary huts in the Thanamalvilla and Sooriyawewa areas, near the sugarcane area, where there are a higher incidences.

Role of risk mapping in malaria control:

a. Planning
b. Targeting
c. Resource management
d. Implementing
e. Forecasting
f. Stratification
g. Larviciding
h. Impregnating bed nets could be started and maintained

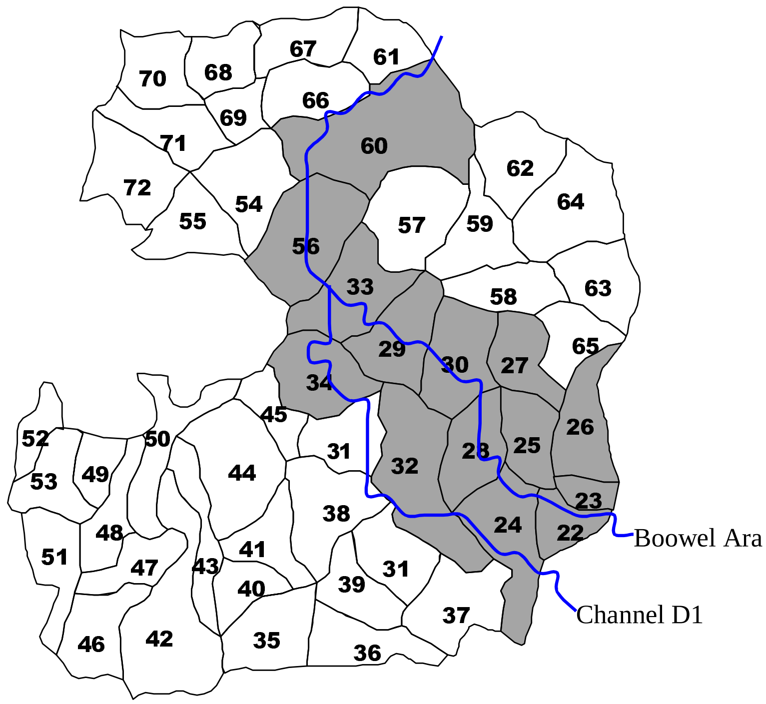
Felix Amerasinghe stated that in addition to these factors evaluations and control strategies could be done. Mr. Munasingha agreed to this.

Dr. Gunawardena asked Mr. Munasighe what the most significant factors contributing to malaria transmission were in the Embilipitiya DSD. He replied that there were many factors contributing to malaria transmission such as parasite reservoir, vector breeding and that these factors, together with the migration of the population, were responsible for the malaria prevalence in the Embilipitiya DSD.

Presentation: Angunukolapelessa DSD
By Mr. D.S.K. Devasiri, PHI AMC

High risk areas:

Angunukolapelessa (22)
Achariyagama (23)
Yakagala (24)
Aluthwewa (25)
Kankanaagama (26)
Binkama (27)
Helakada (28)
Dandenigama (29)
Karagahawela (30)
Jandura (32) - part
Pahalagama (33)
Soriyapokuna (56)



According to the group there was no local transmission of malaria in 1999. All the cases were imported to the area. Water is in short supply part of the time and people move to an area where there is no water problem and return with the disease. In addition, people go to the Thanamalvilla area for *chena* cultivation and return with the disease. Another group of imported cases were the people of the area who served in the Sri Lanka Armed Forces, who were located in the North and the East of the country.

In GN 51 only 10 cases had been recorded and it was apparent that there was not much disease reported from that area.

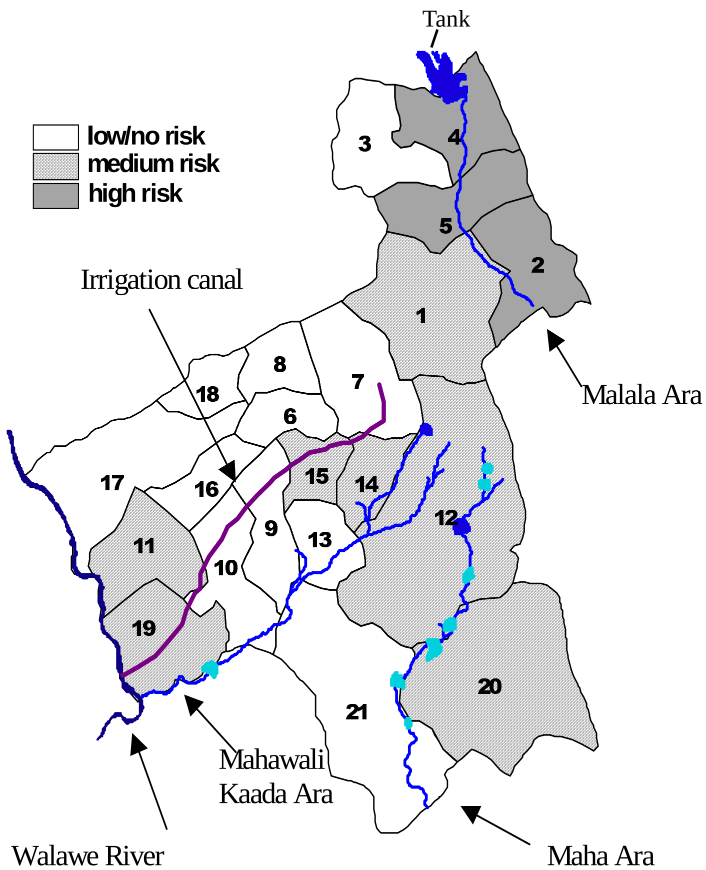
Environmental risk factors:

a. Migrant cultivators from Moneragala
b. Returning personnel attached to the Sri Lanka Forces and operating in the North and the East
c. Surface water (minimum effect)

Role of risk mapping in malaria control:

In control activities for screening of fever cases, prophylactic treatment and identification of parasites and ability to adopt an eradication process.

Presentation: Sooriyawewa DSD
By Ms. B.S.L. Peiris, RMO Hambantota



High risk areas:

- High risk:
- Mahagalwewa (4)
- Meegahajandura (5)
- Ranmududwewa (2)

Moderate risk:

- Ihala Kumbukwewa (3)
- Weliwewa (1)
- Andarawewa (12)
- Wediwewa (20)
- Mahawelikada ara (14)
- Beddewewa (15)
- Weniwelara (11)
- Bedigantota (19)

Low risk

- Rest of the area

Environmental risk factors:

1) Main water sources in the area:

- Malala ara
- Maha ara
- Mahawelikada ara
- Walawe ganga
- Weniwel ara
- Andarawewa
- Mahagal wewa
- Ihala Kumbukwewa
- Pahala Kumbukwewa
- Maha indiwewa

2) Potential breeding places

- Pooling rivers and streams, especially Malala ara, Maha ara, Mahawelikada ara. The Walawe River pooled periodically and it was only the stretch halfway that ran through Sooriyawewa. In general, pooling occurred between June-August.
- In the Northeast of the DSD some breeding areas are created by heavy rains.
- Seepage water of tanks.
- Gem pits (Bedigantota).
- Irrigation canals

3)Vegetation and cultivation pattern:

- scrub forest
- cultivation mostly during the "Maha" season

4) Socio-economic level and economic standards in the Sooriyawewa DSD were very low. In the Malala Ara area people were economically poorer than in the other areas: 90% of the houses were constructed of wattle and daub *(mud) and have thatched roofs and are located by the stream. Water scarcity is a major issue. There are dry and wet periods and water sources completely dry out in the dry season and residents leave the area during this season and return to live by the Malala Ara during the wet season. Additionally people dig holes in the riverbed to remove water and these holes develop into breeding places.*

Along the Maha Ara there are more breeding sites and this area could be identified as a high risk area. There is a moderate risk in Malala Ara, Mahawelikada Ara and the Walawe areas.

Role of risk mapping in malaria control:

Risk maps could be used for malaria control strategies. With these strategies it would be possible to carry out selective malaria control work. If detailed risk maps were made available for the area they could work in a more organized manner.

Presentation: Ambalantota DSD
By Mr. C. Weerasinghe, PHI AMC

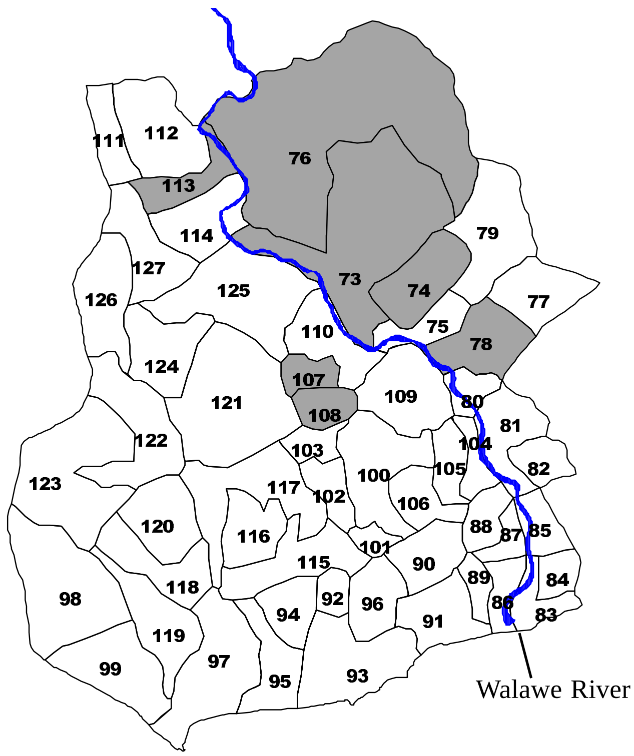
High risk areas:

Ambalantota is not a risk area, 75% of the area is under irrigated paddy cultivation.

Seven "risk" GNs:
Liyangastota (76)
Thaligala (113)
Ridyagama (73)
Punchiheyanagama (74)
Modarapilawala (78)
Mamadala north (107)
Mamadala south (108)

Around Ridiyagama tank due to chena cultivation and gem pits.

Number of cases:
1999: Pv 8; Pf 0
2000: Pv 38; Pf 0
(MOH Ambalantota)



Environmental risk factors:

Possible risk factors:

1. Irrigation channels
2. Abandoned gem pits
3. Walawe River during drought
4. *Chena* cultivation around the Ridiyagama tank
5. Socio-economic factors: poverty and most houses are constructed with wattle and daub and thatched roofs.
6. Migration of people: they migrate to chena areas in the Maha season

Ad 1) irrigation channels: Mamadala canal, Ridiyagama canal, Katchigal Ara
Ad 2) Abandoned gem pits: Ridiyagama, Baminiyanwila, Liyangasthota
Ad 4) Chena cultivation: Karambagalmulla, Ridyagama

Role of risk mapping in malaria control:

1. Early planning of control programs
2. To plan and implement mobile clinics and indoor residual spraying
3. To identify the potential breeding places in time

6. OVERVIEW AND DISCUSSION OF PRESENTATIONS

As was clear from the five presentations, the DSDs have distinct differences in risk factors. However there were common factors such as the contribution of rivers and slow flowing streams and especially the pooling in the riverbeds.

The following points were raised in the general discussion, which followed the presentations:

1. Ms. Peiris, RMO of Hambantota and Mr. Wimalarathna, Senior PHI of the AMC Hambantota area brought up the fact that at the moment the DSD was experiencing a relatively low risk of malaria except for certain GNs (see presentation DSD Sooriyawewa). But they expected that following the completion of the area coming under construction of the Walawe Extension Project, changes would take place and that there would be an increased risk of malaria in the area. This increased risk would be due to the fact that the canals were under construction for a long time and this would create additional breeding sites during the construction phase.

2. A second important point raised in this discussion was the fact that specific structures, so called “drop structures”, were being built by the Mahaweli. According to Mr. Wimalarathna, these structures formed major breeding sites for mosquitoes and close to 5000 of these structures were to be built in the area. This was clearly a point of major concern for the Sooriyawewa health staff and they specifically made a request from IWMI to liaise with the Mahaweli and advise them to use different types of structures instead of those being currently built.

   It was stated that the Mahaweli currently releases water every 14-18 days. According to the health staff it was better if the Mahaweli could release water every seven days in order to prevent mosquito breeding or if they could introduce flushing to wash out the mosquito larvae completely.

   Felix Amerasinghe replied that the first step for IWMI would be to liaise with the Mahaweli and find out what these structures were and then confirm that these structures were indeed a major mosquito breeding source. Once this was established IWMI could look into the possibility of meeting with the relevant authorities of the Mahaweli and discuss the change to the structure design.

3. A point raised by Mr. Siripala, PHI-FA of the Thanamalvilla area was that most other DSDs had mentioned that a risk factor in malaria transmission was imported cases from the Thanamalvilla/Moneragala area by people moving to these areas for *chena* cultivation and returning with malaria to their DSDs. He therefore suggested that there should be a focus on control in this area, which would help diminish the risk in other areas and towards this end more resources should be allocated to this area.

4. Mr. Dewasiri, Senior PHI of the AMC in Hambantota area raised the issue of people visiting private hospitals for treatment of malaria. He said that in the Angunukolapelessa DSD up to 70% of the people consulted private doctors. The reason for consulting private doctors was adduced to the reduced waiting time. This statement was followed be a request to the other DSDs to estimate (in percentage) the number of people consulting private facilities in their DSDs.

The figures were as follows:

a. Thanamalvilla 52% (based on a study by Abeysekara et al 1997, the article indicates 45.5% for the Moneragala and Buttala DSDs in Moneragala)

b. Embilipitiya 20-25%

c. Sooriyawewa 20%

d. Ambalantota 15-20%

e. Angunukolapelessa 70% (as stated above)

The figures varied widely between the different DSDs, and additional data collection is needed for verification.

It was also stated that there existed a practice, that was never reported, which was the under prescribing of drugs resulting in people having to consult the health facility several times. This was a very serious problem, since apart from not curing the people it could also induce resistance in parasites for malaria drugs. For instance Fansidar was always prescribed too late and not as advised by the AMC.

5. Mr. Shermath, a Senior Entomologist of the AMC Hambantota was of the opinion that it was questionable whether the abandoned tanks were breeding sites for mosquitoes. According to him a lot of malaria mosquitoes breed in the seepage water from the tanks and not in the tanks itself. Dr. Felix Amerasinghe stated that the abandoned tanks may not be a breeding site for the major vector (*An. culicifacies*) but that they could very well contribute to the breeding of possible secondary vectors (*An. vagus, An. annularis*). These latter two species were found breeding in the abandoned tanks during the field visit on the March 28 (see chapter 7). Further study would be need into the importance of these secondary vectors in malaria transmission in the area.

Follow Up

Several rivers were mentioned by name and attempts will be made to locate them on the maps and study them in more detail. A method should be found to include the streams as a parameter in the risk analysis. For example, the length of streams and rivers in a GN could be included as a parameter. However possibly even more important are the type of river and the role the underground, sand or rock, could play in pooling as well as the vegetation types growing along the rivers. Therefore it would be necessary to carry out some field research to find out which type of rivers are used for breeding and under what kind of condition by which vectors.

7. FIELDTRIP REPORT

On the March 28, 2001 a fieldtrip was conducted in the area of Thanamalvilla to investigate weather the so-called abandoned tanks, as indicated on the topographic area maps, could serve as mosquito breeding sources. Participants of the fieldtrip were Dr. Felix Amerasinghe, Dr. Dissanyake Gunawardena, Mr. Lal Muttawatta, Ms. Eveline Klinkenberg and Mr. Nissanke PHI of Thanamalvilla.

Eight tanks were visited in the area (see figure 4) The tanks could roughly be divided in two groups, tanks with vegetation all around (see figure 5a) and more muddy tanks with cattle footprints (see figure 5b). Some tanks were a combination of the two (see figure 5c).

In all tanks larval samples were taken, table 1 shows the mosquito species found in the different tanks.

From Table 1 it can be seen that the main malaria vector for Sri Lanka, *An. culicifacies* was not found breeding in the abandoned thanks but some possible secondary vectors were found: *An. annularis* and A*n. vagus*. However, additional larval studies in more tanks are necessary to give decisive conclusions. Additional research should reveal the importance of these species in the transmission of malaria for the area.

A second finding of the fieldtrip was that to so-called abandoned tanks were in practice not abandoned and were still being used by farmers for collecting water. Tanks were either privately owned or owned by Farmers Associations, who together took care of the maintenance of the tanks. Additional studies should be undertaken to investigate how many tanks are still being used and fill up with water during the rainy season.

Table 1. Characteristics of the tanks and mosquitoes found.

Tank nr	Name tank	# dips/ sample	Mosquitoes found	Ffauna	Vegetation	Bottom	Water	Light	Characteristics
1	Taligala wewa	30	*An. vagus*	water beetle		mud	turbid	exposed	low water; mosquito breeding in animal footprints
2	Suriya Godana Wewa	30	*An. annularis*	water beetle	algae, grass	mud	clear	exposed	vegetation till the edges, clear water
3	Uru Horé wewa	30	*An. annularis* *An. vagus*		algae	mud	clear	exposed	mixed vegetation, till the edges, algae in the tank, rock pools formed in the bund of the tank
	rock pools in bund tank 3	6	*An. annularis* *An. vagus*			rock	clear	exposed	Rocks were lying in the bund in which pools were formed.
4	little Sigeria"	30							rock pool, no larvae found
5	Indurugaswewa	30	*An. pediteaniatus* *An. barbirostris*		dead leaves	mud	clear	exposed	vegetation till the edges, clear water, some parts sand
6	Paluwatta Karametiya	30	*Cx. pseudovishuni*		algae, Leersia	mud	clear	exposed	vegetation till the edges, green algae (spirogyra) in tank, muddy place
7	Bimpokunugama	30	no larvae						vegetated tank, lilies, lotus, lots of grass
	road pools near tank 7	30	*An. vagus* *Cx. pseudovishuni*			mud	turbid	exposed	muddy road pools
8	Kukulkatuwa	30	*An. annularis*		Spirogyra, grass	mud	turbid	exposed	vegetation till edges at part of the tank other part muddy with footprints

Figure 4. Tanks visited and mosquito species found during the fieldtrip in Thanamalvilla area, March 28, 2001.

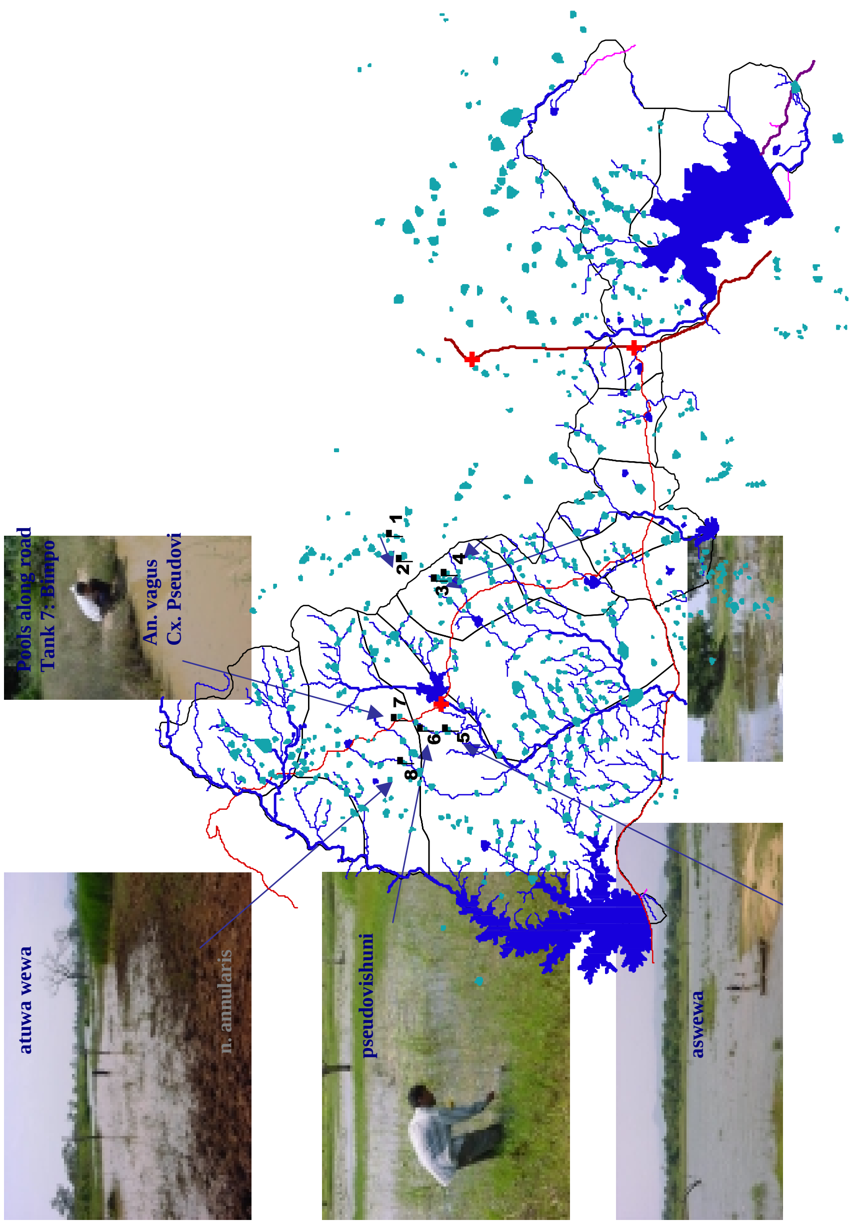


Figure 5. View of several tanks visited in the Thanamalvilla area on the 28th March 2001.

8. REFERENCES

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2. Konradsen, F., Amerasinghe, F.P., van der Hoek, W. and Amerasinghe, P.H., 2000. Malaria in Sri Lanka. Current knowledge on transmission and control. IWMI.

9. LIST OF ABBREVIATIONS

AMC	=	Anti Malaria Campaign
API	=	Annual Parasite Index
DPDHS	=	Deputy Provincial Director of Health Services
DSD	=	Divisional Secretary Division
EIR	=	Entomological Inoculation Rate
FA	=	Field Assistant
FR	=	Falciparum Ratio
GIS	=	Geographical Information System
GN	=	Grama Niladari area
MOH	=	Medical Officer of Health
Pf	=	Plasmodium falciparum
PHI	=	Public Health Inspector
Pv	=	Plasmodium vivax
RMO	=	Regional Malaria Officer
RS	=	Remote Sensing

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