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The final report of the APW to provide technical support to EDCD in conducting micro-stratification of malarious zones in Nepal.

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Micro-stratification of Malaria Risk in Nepal

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Glossary

API	Annual Parasite Incident
APW	Annual plan of work
BCC	Behavioral Change Communication
CBS	Central Bureau of Statistics
CDC	Center for Diseases Control
DHO	District Health Office
EDCD	Epidemiology and Disease Control Division
EDPT	Early Diagnosis and Prompt Treatment
EPHS	Essential Public Health Services
GFATM	Global Fund for AIDS, Tuberculosis and Malaria
GIS	Geographical Information System
GPS	Global Positioning System
HMIS	Health Management Information Centre
ICIMOD	International Centre for Integrated Mountain Development
IRS	Indoor Residual Spraying
JANS	Joint Assessment of National Strategy
KAP	Knowledge Attitude and Practice
LLIN	Long Lasting Insecticide Treated Net
MOHP	Ministry of Health and Population
NMEO	National Malaria Eradication Organization
NMP	National Malaria Program
NPO/MAL	National Professional Officer, Malaria Programme
PMU	Programme Management Unit
PSI	Population Services International
RDT	Rapid Diagnostic Test
SEARO	South East Asia Region
SoPs	Standard Operating Procedure

ToR	Terms of Reference
TWG	Technical Working Group
VBDRTC	Vector-Borne Disease Research and Training Center
VCI	Vector Control Inspector
VDC	Village Development Committee
WHO	World Health Organization
WHRC	World Health and Research Center

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Micro-stratification of Malaria Risk in Nepal

Executive Summary

Micro stratification of malaria risk was carried out during 2012 following the recommendations of Independent External Review in 2010 and Joint Assessment of National Strategy (JANS) in 2011 in order to deploy appropriate and effective malaria control interventions for facilitation of a successful malaria elimination program in Nepal.

Under the overall oversight of Epidemiology and Disease Control Division (EDCD) and technical facilitation of WHO, an independent professional resource group WHRC in the center and three independent regional data collection and verification teams were outsourced for designing and execution of the micro stratification activity. Appropriate questionnaire, forms, formats and guidelines were developed to collect basic information for malaria micro-stratification and were pre-tested in Kavre district Primary Health Care Center for necessary adaptations, corrections and adjustments. Basically, the Village Development Committee (VDC) based questionnaire template was designed into two parts, the first contained demographic, geo-ecological, meteorological, socio-economic and entomological information, whereas the second part contained malaria disease, diagnosis and treatment, classification and containment information including vector control. The Malaria Technical Working Group (TWG) meeting reviewed and endorsed the forms, format and guidelines for the malaria micro-stratification. Regional data collection teams and district health teams were trained to familiarize with the forms and formats and to correctly feeding the given templates either manually or electronically. As a priority, VDC based basic malaria information was collected from 31 districts were collected in the first phase, which reported 92% of malaria cases of the country. At a later date, data from rest of the 44 districts were collected in the second phase. The data received from the concerned districts and agencies were processed and stored at EDCD and a reporting and the analysis system established. A template was developed centrally for compilation, cleaning and validation of data with a regular feedback to the regional teams. Standard reports were designed in Ms Access to retrieve the data as required.

VDC wise basic malaria information was analyzed using exploratory statistical analysis and also in GIS environment, to identify variables that contributes to malaria risk in Nepal. Three major categories, i) disease burden, ii) entomological risk at various ecological settings, and (iii) vulnerability-population movement, were identified. Due to the paucity of recent entomological information, historical evidences were taken into consideration and a meta-analysis of various malaria entomological reports and information was carried out through an entomological workshop which outlined the malaria transmission risk by ecological settings of Nepal. To identify transmission risk at VDC level, overlay analysis was done in GIS Environment using ArcGIS 10. Three GIS data layers, (i) land-use derived from Thematic Mapper (TM), 2010 (ii) VDC boundary, and (iii) ecological zone, were overlaid. Various analytical methods were reviewed and explored to obtain

cumulative risk and finally "scoring methodology" was selected, as the use of this qualitative method ensures that the risk assessment steps are transparent, reproducible and comprehensible.

A tool devised by Center for Diseases Control (CDC) to assess Essential Public Health Services performance was adopted to identify areas of malaria risk in Nepal, where each indicator establishes a weight, and then multiplies the weight by the response value to obtain a weighted value for each indicator. These weighted values are combined to construct the overall risk score. This methodology is implemented through the three steps. Both qualitative and quantitative variables are converted to qualitative variables. A four-point, Likert-type response, is assigned to each variable.

Four different scoring methods were considered, applying different scores to different variables using 2009 to 2011 data, and finally decided on assigning (i) disease burden-average API-a "0.3" wt.; (ii) ecology- vector and transmission risk-a "0.5" wt.; and (iii) vulnerability-population movement-a "0.2" wt., putting much weight on ecology and transmission risk as it was considered epidemiologically credible because of the importance of transmission risk potential putting emphasis on ecology, vector and transmission environment.

Operational definition of malaria risk of a VDC was formulated based on overall score which ranged from 0 to 100 and classified into four categories: i)no risk-historically there is no evidence of malaria transmission including in the last three years; ecology not favorable for transmission and maximum overall score a VDC can get based on vulnerability is (0.2*1)*100 = 20% or less; ii)low risk- historically with evidence of transmission, but no indigenous case in the last three years; average three-year API = 0; ecology is favorable for transmission and overall score a VDC can get based on vulnerability, geo-entomological risk is (0.2*1+0.3*1)*100 = 50% or less; iii)moderate risk-historically with evidence of transmission and there are indigenous cases in the last three years; average three-year API is less than 1/1,000 population; malaria risk is present due favorable ecology and overall score based on vulnerability, geo-entomological risk, disease burden is (0.2*1+0.3*1 +0.5*0.6)*100 = 80% or less; and, iv)high risk-historically with evidence of transmission and there are indigenous cases in the last three years; average three-year API = equal to or greater than 1/1,000 population; malaria risk is present due favorable ecology and overall score based on vulnerability, geo-entomological risk, disease burden is (0.2*1+0.3*1 +0.5*1)*100 = 100% or less.

The malaria risk stratification takes into account several key determinants of malaria transmission e.g., disease burden (API- malaria cases per 1000 risk population) in the last three years; ecology that determines the presence of the vectors, relative efficiency of the vectors in malaria transmission, duration of transmission in ecological zones; and vulnerability in terms of population movement. The key determinants (termed as major variables) are given weights to stratify the malaria risk.

The annual parasite incidence (API) averaged over the period 2009 to 2011 was taken as a determinant of disease burden. A total 44 VDCs (1.10%) reported average API higher than one came under high burden, 752 (18.91%) VDCs reported average API between 0.01 and 0.99 came under moderate burden, and 3176 (79.88%) VDCs reported no malaria cases in this period (i.e., average API = 0) came under low burden. According to scoring criteria, VDCs with high burden received 1, the highest response value, moderate burden VDCs received response value 0.6 and low burden VDCs received 0.1 response value. The weight a VDC got based on disease burden is 0.3 out of 1. Though response values ranged from 1 to 0.1, actual score VDCs received, ranged from 0.3 to 0.03 as the study analysis time frame is three years (i.e., 2009 to 2011).

The second determinant, entomological risk of malaria transmission was mainly derived on the basis historical evidences. The entomological risk, characteristics of vectors and transmission potential is determined by ecological setting. There are five ecological zones: plain outer Terai, inner Terai (valley in between Shiwalik and Mahabharata ranges), hill, Middle Mountain and High Mountain. Due to various climatic factors and altitude, transmission potential of same species of vector varies accordingly in different ecological setting of Nepal. Combination of ecological zone, landuse characteristics and presence of malaria cases were analyzed in GIS environment, to derive entomological risk of malaria transmission. Plain outer Terai VDCs were subdivided into two categories, forest ecosystem (high transmission potential) and cultivated areas (low transmission potential) based on landuse 2010. Inner Terai came as high or moderate transmission potential and the remaining three ecological zones came under low transmission potential. Altogether 97(2.44%) VDCs came under high, 206 (5.18%) VDCs came under moderate, and the rest 3605 (92.18%) came under low transmission potential. According to scoring criteria, VDCs with high transmission potential received 1, moderate burden VDCs received response value 0.6 and low burden VDCs received 0.1. The weight a VDC got based on ecology was 0.5.

The third determinant, vulnerability was measured in terms of population movement. VDCs reporting regular movement to forest with overnight stay, has ongoing development projects or resettlement activities were assigned to high vulnerability category. VDCs reporting movement to high risk states of India and high risk VDCs of the country were assigned to moderate vulnerability category, VDCs reporting movement to endemic areas of the country as well as other countries and limited movement to forest were assigned to low vulnerability, and movements to non-endemic areas were classified as no risk. As a result, 686 (17.25%) VDCs came under high vulnerability and 3290 (82.75%) VDCs came under low vulnerability. None of the VDCs came under moderate vulnerability. According to scoring criteria, VDCs with high vulnerability received 1, VDCs moderate vulnerability received response value 0.6 and low vulnerability VDCs received 0.1. Weight a VDC got based on ecology was 0.2.

Analyzing overall risk based on scoring **(Disease burden with weight 0.3, Ecology with weight 0.5, and Vulnerability wih weight 0.2)**, 54(1.36%) VDCs came under high risk category, 201(5.06%) VDCs came under moderate risk category, 999(25.13%) came under

low risk cateogry and 2718(68.36%) came under no risk category. A total population of 985,636(3.62%) live in high risk VDCs, 2,660,692 (9.79%) live in moderate risk VDCs, and 9,378,735 (34.52%) live in low risk VDCs. A total population of 14,139,920(52.05%) live in no risk VDCs.

Most of the high risk VDCs are seen in the Far-western (19 VDCs) followed by Mid-western region (18 VDCs). Central and Western regions have 10 and 7 VDCs under high risk respectively where as there are no high risk VDCs in the Eastern region.Altogather, 77 VDCs of the Central region came under moderate risk, followed by the Mid-western (59 VDCs), Western (27 VDCs), Eastern (24VDCs) and the rest (14 VDCs) from the Far-western regions. A total of 353 VDCs of the Central region followed by the Eastern (215 VDCs), Western (191 VDCS), Far-western (148 VDCS) and Mid-western (92 VDCs) regions were classified under low risk. Most of the no risk VDCs (778 VDCs) came from the Central region, followed by the Eastern region (668 VDCs) and the Western (652), Mid-Western(region (412 VDCs), and the Far-Western(208 VDCs) regions.

There were certain limitations in the present study- i) does not take into account the large number of clinical cases and excluding clinical cases may have underestimated the malaria risk, ii) case investigation and classification are vague to determine the presence of local transmission and to track the origin of the case. iii) do not include cases from private facilities and government hospitals, iv) lack of current study in entomology. over the years, there are so much ecological changes and high usage of insecticides that might have led to changes in vector bionomics, and v) due to large variation in topography and ecology within the VDC a lower level either a ward or village be identified for future updating of malaria risk.

There are suggestions to update and refine the risk stratification (within 2 and every 3 years thereafter): Validate the risk stratification, surveillance system be strengthened, all cases be confirmed either by microscopy or RDT, establish computerized database of every case with link to GIS map, cases be recorded by ward or village, all positive cases be investigated and classified, geo-reference of the case should be recorded using GPS, update the entomological information by study on vector bionomics (in selected ecotypes in east, mid-west, and far- west), entomological surveys in as many VDC as possible with different ecotype. The present study has also indicated stratum wise specific interventions based on the present micro-stratification.

1. Introduction:

An independent external assessment team commissioned by the World Health Organization **(WHO) in 2010 and also in 2011, a Joint Assessment of National Strategy (JANS) of Malaria** Control Strategy on request of the Ministry of Health and Population (MoHP), strongly recommended that the current stratification of malaria risk areas be updated as early as possible in order to deploy appropriate and effective malaria control interventions for facilitation of a successful malaria elimination program in Nepal. As a result the World Health Research Center (WHRC), Kathmandu, a professional resource group was contracted by WHO to provide technical support to National Malaria Program (NMP) in Epidemiology and Disease Control Division (EDCD) in conducting micro-stratification of malarious zones(malaria risk) in Nepal.

The WHRC Team comprised of five members, a malariologist, a GIS specialist, an epidemiologist, an assistant epidemiologist and a data assistant were engaged from 1 July 2012 to provide technical support to EDCD/NMP in conducting micro-stratification of malarious zones (malaria risk) in Nepal.

2. Objectives:

The main objective of the activity is to provide technical support to EDCD/NMP in conducting micro-stratification of malarious zones (malaria risk) in Nepal.

- Support EDCD in the development of the plan guideline forms and formats for the collection of the information on disease, vector, parasite, terrain to conduct malaria micro-stratification.
- Follow up with three micro-stratification regional teams for the collection of the information on disease, vector, parasite, terrain to conduct malaria micro-stratification.
- The database will be established on disease, vector, parasite and terrain at EDCD and submitted to WHO Country office.
- The data will analyze on disease, geography, vectors, and parasite received, in GIS environment.

3. Questionnaire design:

The WHRC team developed forms, format and guidelines to collect basic information for malaria micro-stratification of malarious zones (malaria risk) in Nepal. Basically, the Village Development Committee (VDC) based questionnaire template was designed into two parts, the first contained demographic, geo-ecological, meteorological, socio-economic and entomological information, whereas the second part contained malaria disease, diagnosis and treatment, classification, severity/death, drug resistance status and containment information including vector control. The team organized various technical consultation meetings with EDCD, Program Management Unit/GFATM, and WHO Country Office for development of these documents.

Pre-test of the developed forms, format and guidelines were carried out at Panchkhal Primary Health Center of Kavrepalanchowk, in co-ordination with the District Health Office (DHO). In

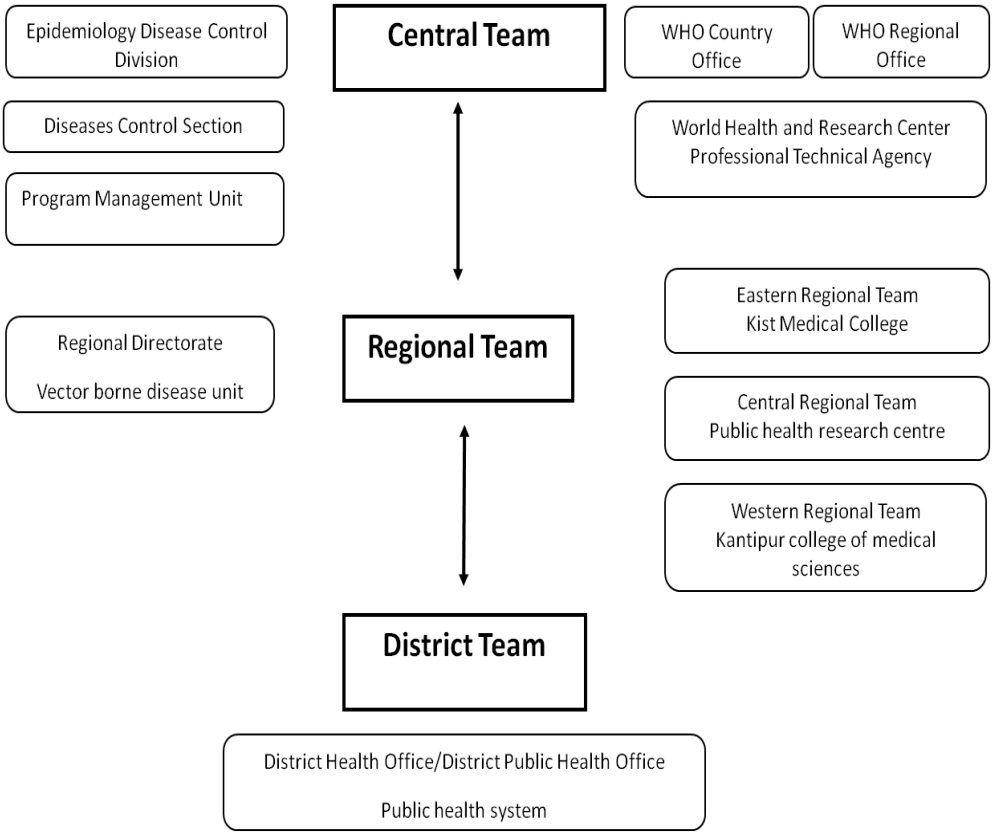
this exercise all the partners; EDCD/NMP, PMU/GFATM, DHO, Kavrepalanchowk; WHRC team and WHO Country Office, were involved. The forms, format and guidelines were updated by incorporating the necessary changes. Annex 1 contains the forms, formats and guidelines.

The Malaria Technical Working Group (TWG) meeting was held on 16th July 2012 to review and endorse the forms, format and guidelines for the malaria micro-stratification. All the comments received from the expert group were incorporated in the tools of malaria micro-stratification and finalized.

4. Data collection:

Data for micro-stratification were collected in two phases. In the first phase it was collected and analyzed from 31 priority districts which report more than 92% of malaria and 96% of *P.falciparum* of the total confirmed malaria cases of the country. Data collection of remaining 44 districts were carried out at a later stage in the second phase, these districts contribute less than 10% of total malaria cases and where either there are negligible number of malaria cases or no malaria cases historically reported over the years.

Figure 1: Composition of malaria micro-stratification team



To collect basic VDC/municipality wise malaria information, regional teams were formed with the leadership of an experienced entomologist, a data manager and a laboratory technician. Similarly the district teams were also formed with the leadership of the district health officer/distinct public health officer to support the regional teams. The composition of the malaria micro-stratification teams could be seen in Figure 1. Terms of references (ToRs) for the regional

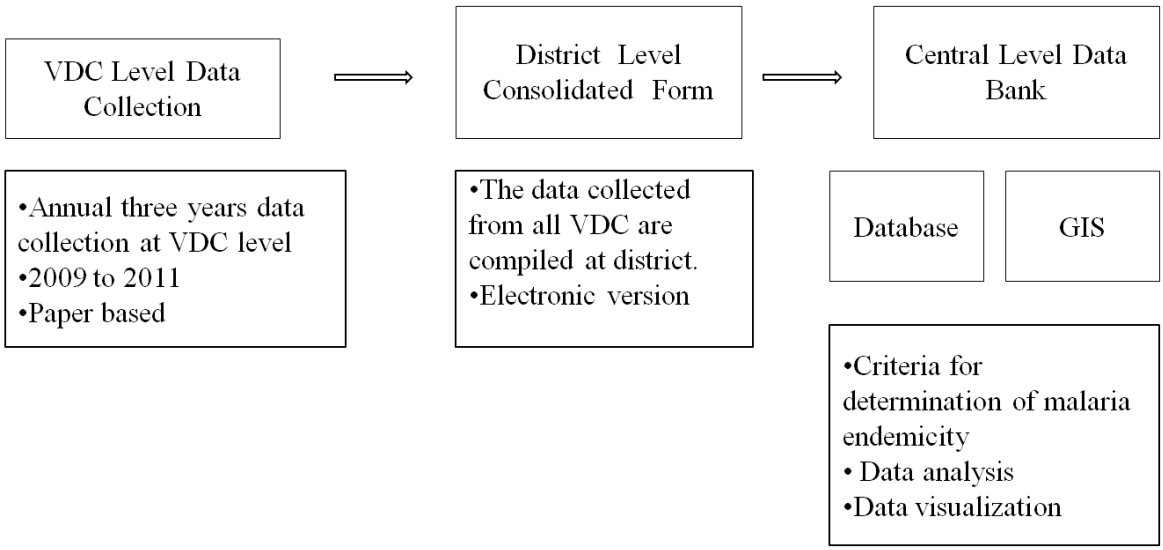
teams and the district teams were prepared with the involvement of EDCD/NMP, PMU/GFATM and WHO. Annex 2 contains ToRs of the regional and the district teams. Orientation for district teams and the regional teams were conducted at various phases with the involvement of EDCD/NMP, PMU/GFATM and WHO. In the orientation, topics such as roles and responsibilities of the teams, process of the data collection, verification, validation and compilation at the district level and its transmission to central team were dealt with.

The regional teams were strategically deployed to the districts for data collection. Simultaneously, the WHRC team collected additional information from various organizations, national and the international experts at central level. The central team collected data from Central Bureau of Statistics, Department of Forestry, Department of Hydrology and Meteorology, Department of Local Development and International Centre for Integrated Mountain Development.

5. Data verification and validation:

The central team received consolidated data and the field reports from the regional teams regularly. The central team developed a template for compilation and validation of data. This template was used for data cleaning and for validation. Feedback was sent to the regional teams on regular basis to review and correct the data.

Figure 2: Process of basic malaria information flow



The central WHRC team visited three regions to validate the data collection process and to provide necessary technical assistance to regional teams. The information was validated against existing malaria positive register, lab register (HMIS-19), tally sheets, HMIS-24, monthly monitoring sheets. Necessary processing was done to convert malaria information from HMIS monthly tally sheets to English calendar year (2009, 2010, and 2011). Validation of IRS information was tallied against the spray proposals and spray reports. The central team also visited some peripheral health facilities to look at the lab register (HMIS-19) and monthly tally sheet.

The central EDCD-VBDs Unit visited sampled few districts among 44 high hill districts where a few indigenous malaria cases were reported. Due to absence of malaria control specific personnel,

the reports were erratic and case classifications were dubious. However, the consolidated data collected were jointly verified by WHRC and VBDS Unit, which was compiled and validated using template developed during data validation of 31 priority districts

6. Establishment of reporting and the analysis system

The requested data received from the concerned agencies were processed and stored at EDCD. The WHRC central team has compiled the basic malaria information which was collected from various agencies. Standard reports were designed in Ms Access to retrieve the data as required. This database contains VDC level basic malaria information, collected by the regional teams, population from Central Bureau of Statistics, LLIN distribution data from PSI, drug resistance information from national experts, data regarding altitude (elevation) and land use from ICIMOD. Recently acquired data from the department of the meteorology and hydrology will also be incorporated in database. Additionally a workshop on malaria entomology was conducted in order to perform a meta-analysis of existing malaria entomological reports and information to ascertain and determine the potential risk of transmission of malaria in different ecological settings

7. Methodology:

The central team analyzed VDC wise basic malaria information using exploratory statistical analysis and also in GIS environment, to identify variables that contributes in malaria risk in Nepal. Three major categories were identified, which were i) disease burden- average API, malaria cases per 1000 risk population, ii) entomological risk at various ecological settings-ecology and malaria vectors, and (iii) vulnerability-population movement. Received entomological data was not sufficient to draw inferences on entomological risk for malaria transmission. So, a workshop was organized to obtain required entomological information based on historical evidences. The workshop on malaria entomology made efforts to perform a meta-analysis of existing malaria entomological reports and information to ascertain and determine the potential risk of transmission of malaria in different ecological settings.

The team also reviewed and explored various analysis methods to obtain cumulative risk and finally decided to use scoring methodology, as the use of this qualitative method makes it possible to ensure that the risk assessment steps are transparent, reproducible and comprehensible even to non-experts. The team considered different methods applying different scores to different variables and were presented to EDCD/NMP, PMU/GFATM, VBDRTC and WHO Country Office and also to WHO Regional Advisor. Suggestions provided by the experts have been incorporated in the final analysis.

7.1. Entomological workshop:

A Workshop on "Micro Stratification of malaria risk based on entomological findings in different ecological settings of Nepal" was held with participation of senior malariologist, entomologists and malaria control experts. All the available documents in the EDCD and VBDRTC, documents from personal collections, scientific papers published in journal of Nepal Medical Association and international journals, WHO assignment reports, NMEO and EDCD annual reports, malaria

entomological annual reports and some unpublished data were scrutinized for vector characteristics and their bionomics in relation to malaria transmission. Review of each article was carried out by individual experts followed by in depth discussion and short notes were made to supplement the report. Also, an informal consultation was held to finalize the malaria risk with the participation of EDCD/NMP, PMU/GFATM, VBDRTC, WHO and WHRC.

The workshop documented the characteristics of different malaria vectors and stratified the malaria risk according to the transmission potential of malaria vectors of Nepal in different ecological settings. The detailed document of the workshop is in annex 5.

Table.1: Entomological stratification of malaria transmission risk in different ecological settings

Entommological stratification of malaria transmission risk in different eco-zones												
Eco-Zones	**Vector/s**	**Seasonal prevalence/months**			**Host Preference**	**Biting rhythm hrs**			**Resting and feeding behaviour**	**Breeding habitat**	**Susceptibility to insecticides**	**Transmission risk ***
		Start	**Peak**	**End**	**Anthropophilic or Zoophilic**	**Start**	**End**	**Peak**				
Outer Terai Plain cultivated land(Rice eco-system)	An. anularis	March	Aug	Nov	Zoophilic	7:00 PM	5:00AM	11:00PM	Endophagic-Exophilic	Pond, paddy fields	Resistant to DDT,BHC&Susceptible to OP & Synthetic pyrethroids	Low Risk
Outer Terai-Forest fringe,Forested & foothills(Fluvi-ecosystem)	An. Fluvitialis	Feb	May	Dec	Indiscriminate (Anthropophilic &Zoophilic both)	7:00PM	5:00AM	10:00PM	Endophagic-exophilic, or exophagic-exophilic	Slow running,clear water with marginal and emergent vegetation	Susceptibile to all insecticides	High (Perenneal transmission)&High to moderate transmission
	An. maculatus	Feb	May	Dec	Zoophilic	6:00PM	2:00AM	9:00PM	Endophagic - Exophallic	Slow running,clear water with marginal, emergent vegetation & shallow rice field	Susceptibile to all insecticides	Low
Inner Terai (Forest ecosystem)	An.fluvitia	Feb	Mar-April, Oct-Dec	Dec	Indiscriminate (Anthropophilic &Zoophilic both)	7:00PM	5:00AM	10:00PM	Endophagic-Exophilic, or Exophagic-Exophillic	Slow running,clearwater with marginal and emergent vegetation	Susceptibile to all insecticides	High (Perenneal transmission)&High to moderate transmission
	An. maculatus	Feb	May	Oct	Zoophilic	6:00PM	2:00AM	9:00PM	Endophagic - Exophillic	Slow running,clear water with marginal, emergent vegetation & shallow rice field	Susceptibile to all insecticides	Moderate to Low
Hills&hills river valleys (Hill - river-ecosystem)	An. fluvitialis,	Mar	Aug	Oct	Indiscriminate	7:00PM	5:00AM	10:00PM	Endophagic-Exophilic,or Exophagic-Exophilic	Slow running,clearwater with marginal and emergent vegetation	Susceptibile to all insecticides	Low (Transmission period short)
	An. maculatus	Mar	Aug	Oct	Zoophilic	6:00PM	2:00AM	9:00PM	Endophagic - Exophillic	Slow running,clearwater with marginal, emergent vegetation.	Susceptibile to all insecticides	Low (Transmission period short Jun-Oct)
Mountain and upper river valleys(Hill-river-eco-system)	An. maculatus	Jun	Aug	Sep	Zoophilic	6:00PM	2:00AM	9:00PM	Endophagic - Exophillic	Slow running,clearwater with marginal, emergent vegetation & (terrace type of farming)	Susceptibile to all insecticides	(Transmission period very short (July-sept) Low

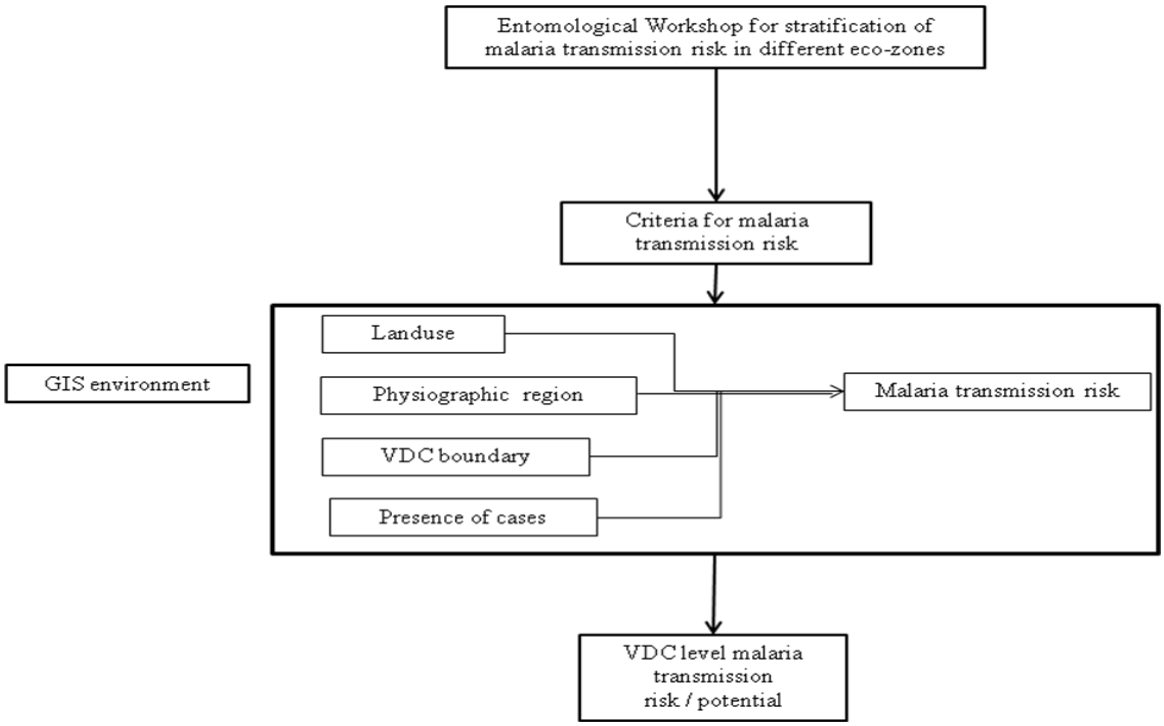
* Risk Criteria for malaria transmission is adapted as per recommendation made by Dr. G.B. White in 1982.

7.2. GIS Analysis:

The entomological workshop outlined the malaria transmission risk by ecological settings of Nepal (Table.8.1). To identify transmission risk at VDC level, overlay analysis was done in GIS Environment using ArcGIS 10. Three GIS data layers (i) landuse derived from Thematic Mapper (TM), 2010 (ii) VDC boundary (iii) Ecological zone, were overlaid. A VDC was considered in a

ecological zone if major part of the VDC fell in the zone. The same principle was applied for landuse as well. A special consideration was given to the VDCs which reported cases in all three years showing persistence of transmission in the inner Terai region is overlaid to further refine the malaria transmission risk by ecological settings.

Figure 3. Flowchart showing steps to derive transmission risk by ecological setting



7.3. Scoring method:

Center for Diseases Control (CDC) devised a tool to assess performance of ten Essential Public Health Services (EPHS). The paper "scoring methodology for revised assessment instruments" is attached in annex 6. The methodology of assessment tool was adopted to identify areas of malaria risk in Nepal. Each indicator establishes a weight, and then multiplies the weight by the response value to obtain a weighted value for each indicator. These weighted values are combined to construct the overall risk score. This methodology is implemented through the three steps. Both qualitative and quantitative variables are converted to qualitative variables. A four-point, Likert-type response, is assigned to each variable. The assessment tool is elaborated in the following table 2.

The team considered four different methods applying different scores to different variables using 2009 to 2011 data. The variables and weight considered for method one were (i) presence of cases with "0.5" wt.; (ii) transmission risk with "0.3" wt.; and (iii) population movement with" 0.2" wt. The variables and weight considered for method two were (i) presence of cases with "0.4" wt.; (ii) transmission risk with "0.4" wt.; and (iii) population movement with "0.2." wt. Similarly, the method three considered (i) average API "0.3" wt.; (ii) transmission risk with "0.5"

wt.; and (iii) population movement with "0.2" wt. The method four considered i) average API "0.4" wt.; (ii) transmission risk with "0.4" wt.; and (iii) population movement with "0.2" wt. All four methods were presented to EDCD/NMP, PMU/GFATM, VBDRTC and WHO Country Office and also to WHO Regional Advisor. The third method was selected putting much weight on transmission risk because of the importance of transmission risk potential stressing emphasis on ecology, vector and transmission environment. It was also considered epidemiologically credible as the main objective of the micro-stratification was to delineate the areas according to the grade (level) of risk of malaria transmission

Table.2: Scoring Methodology for Micro-stratification of Malaria Risk in Nepal

Level 1	**Overall Risk**	**Sum of level 2 *100**		
Level 2 Response * wt	**Indicators (Weight, wt)**	**Disease burden (0.3)**	**Ecology (0.5)**	**Vulnerability (0.2)**
Level 3 Response Value	**Variable** **Response** High(1.0) - **H** Mod(0.6) - **M** Low (0.1) - **N** No (0.0) - **L**	**Annual Parasite** **Incidence in three years** Average API > = 1.0 – **H** Average API is 0.01 to 0.99 – **M** Average API is 0 – **L**	**Transmission risk Combination of geo-ecosystem & vector species** (Refer Table. 1)	**Population movement** Movement to: forest with overnight stay, and development projects: roads/damn construction/ re-settlement – **H**. -high risk districts of the country and to 11 states from India – **M** -endemic districts, endemic countries, and limited movement to forest – **L** -non-endemic areas of the country and abroad– **N**

7.4. Operational definition of risk:

Operational definition was formulated to categorize and draw conclusions on malaria risk. Overall score ranged from 0 to 100, which was classified into four categories based on operational definition.

No Risk: Historically there is no evidence of malaria transmission including in the last three years; ecology not favorable for transmission (e.g., urban areas; high altitude areas); there may be cases but imported from other areas. Maximum overall score a VDC can get based on vulnerability only. A VDC is considered no risk if overall score is (0.2*1)*100 = 20% or less.

Low risk: Historically with evidence of transmission, but no indigenous case in the last three years; average three-year API = 0; malaria risk is present due favorable ecology or there is evidence of presence of vectors, and there is movement of population to/from areas with malaria. Maximum overall score a VDC can get is only based on ecology and vulnerability. A VDC is considered low risk if overall all score is (0.2*1+0.3*1)*100 = 50% or less.

Moderate risk: Historically with evidence of transmission and there are indigenous cases in the last three years; average three-year API is less than 1/1,000 population; malaria risk is present due

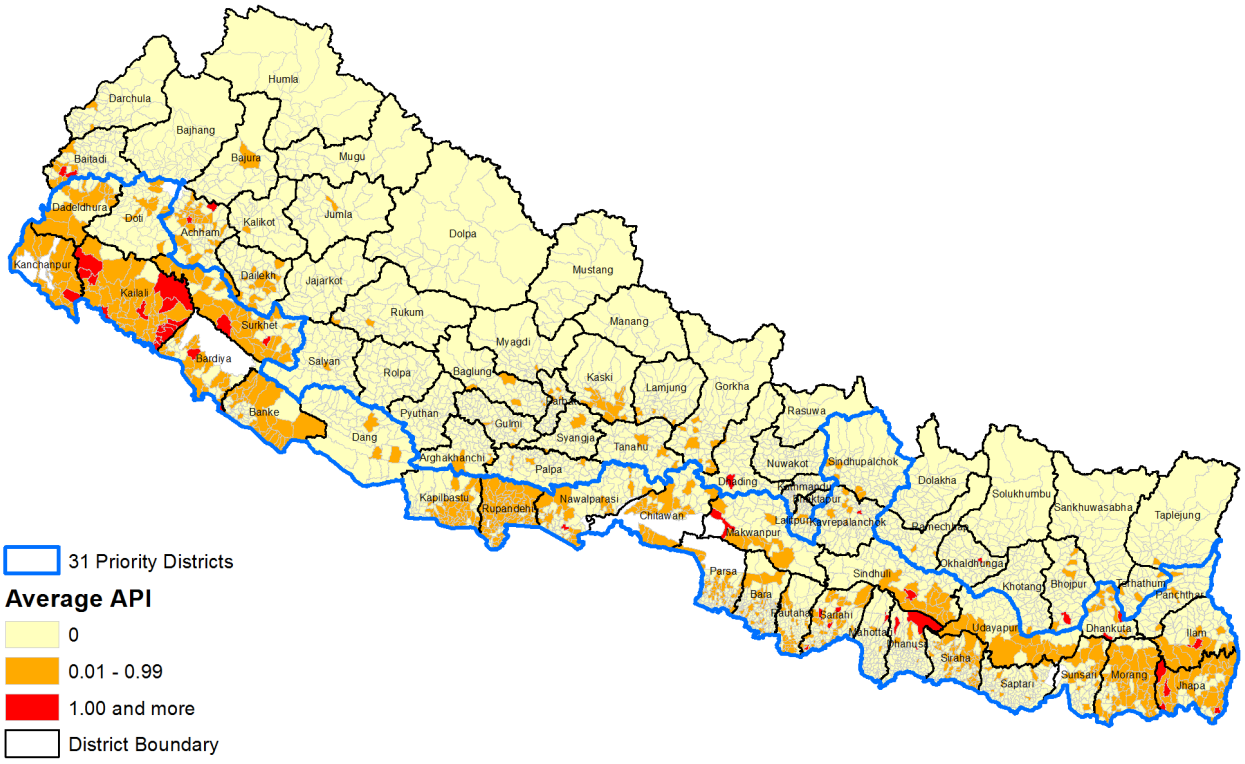
favorable ecology or there is evidence of presence of vectors, and there is movement of population to/from areas with malaria. Maximum overall score a VDC can get based on vulnerability, geo-entomological risk, disease burden is (0.2*1+0.3*1 +0.5*0.6)*100 = 80% or less.

High risk: Historically with evidence of transmission and there are indigenous cases in the last three years; average three-year API = equal to or greater than 1/1,000 population; malaria risk is present due favorable ecology or there is evidence of presence of vectors and there is movement of population to/from areas with malaria. Maximum weight a VDC can get based on vulnerability, geo-entomological risk, disease burden is (0.2*1+0.3*1 +0.5*1)*100 = 100% or less.

8. Result and Discussion:

The malaria risk stratification takes into account several key determinants of malaria transmission (e.g., disease burden (API- malaria cases per 1000 risk population) in the last three years; ecology that determines the presence of the vectors, relative efficiency of the vectors in malaria transmission, duration of transmission in ecological zones; and vulnerability in terms of population movement. The key determinants (termed as major variables) are given weights to stratify the malaria risk. Overall, the stratification of malaria risk areas is robust enough to be used for planning and implementation of key interventions.

8.1. Disease burden:

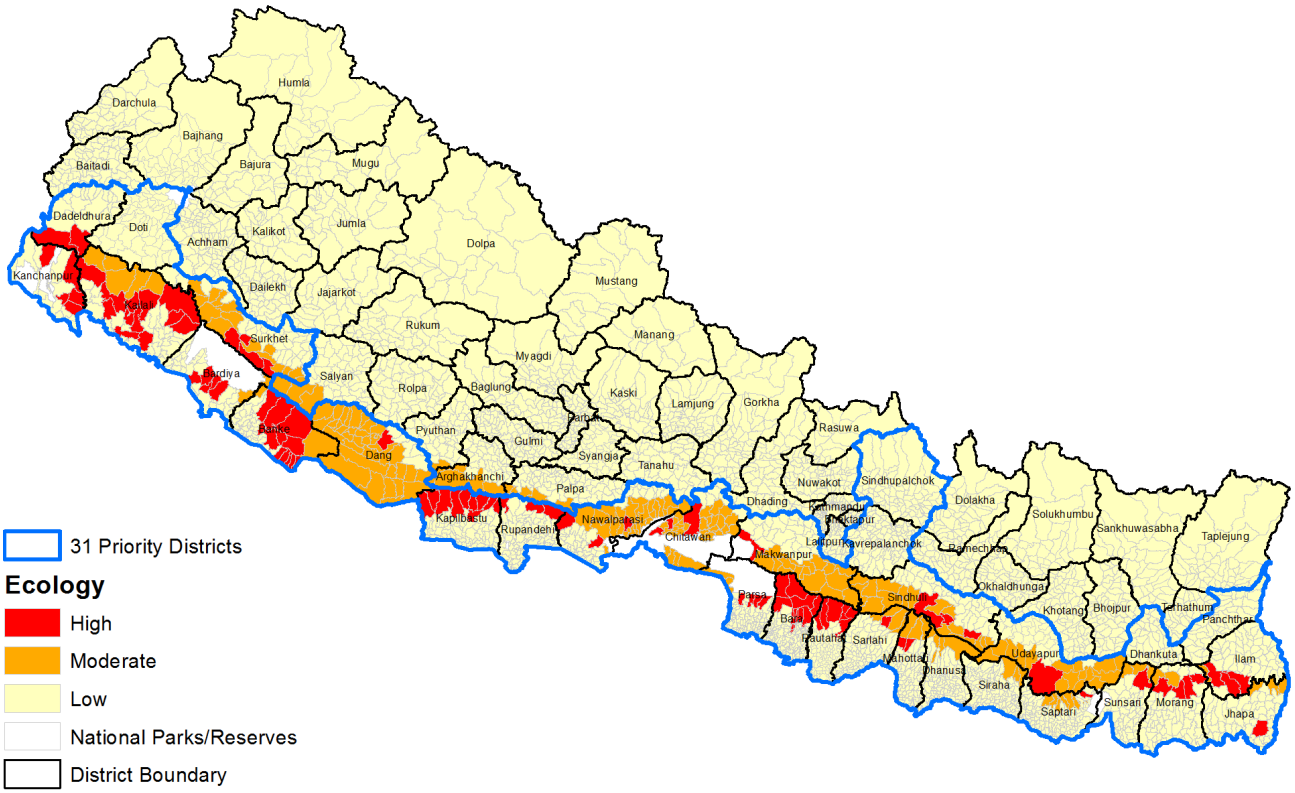


Map 1. Average API from 2009 to 2011 (disease burden)

A total 44 VDCs reported average API value equal to one or greater than one, 752 VDCs reported average API between 0.01 - 0.99 and 3176 VDCs reported no malaria cases in this period (i.e., average API = 0). Hence, 44 (1.10%) VDCs came under high burden, 752 (18.91%) VDCs came under moderate burden, and 3176 (79.88%) VDCs came under low burden. Risk couldn't be determined for 4 VDCs due to missing parameters. Distribution of VDCs according to average API is shown on the Map 1. According to scoring criteria, VDCs with high burden received 1, the highest response value. Likewise, moderate burden VDCs received response value 0.6 and low burden VDCs received 0.1 response value. The weight a VDC got based on disease burden is 0.3 out of 1. Though response values ranged from 1 to 0.1, actual score VDCs received, ranged from 0.3 to 0.03. In this study, analysis time frame is three years (ie, 2009 to 2011).

8.2. Ecology:

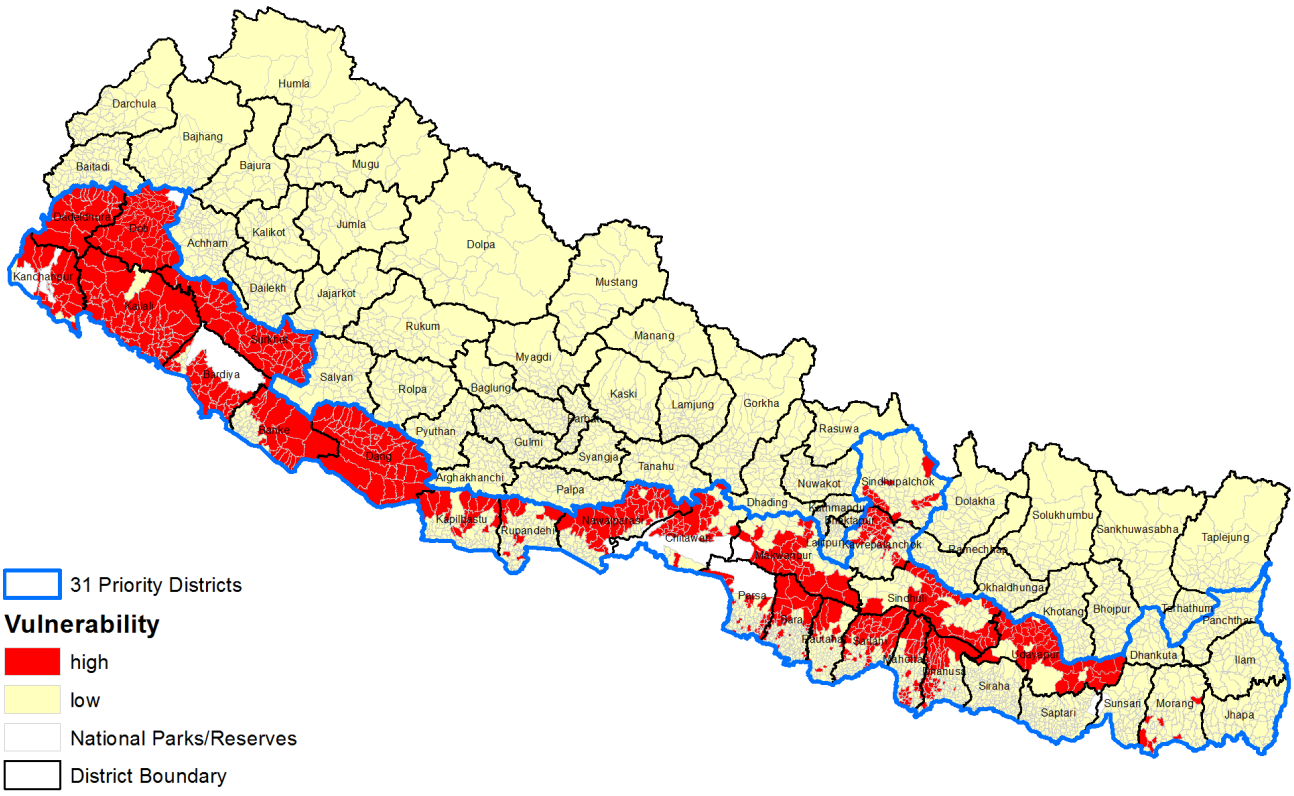
The second determinant, entomological risk of malaria transmission was mainly derived on the basis historical evidences, summarized in the table 8.1. The entomological risk, characteristics of vectors and transmission potential is determined by ecological setting. There are five ecological zones: plain outer Terai, inner Terai (valley in between Shiwalik and Mahabharata ranges), hill, Middle Mountain and High Mountain. Due to various climatic factors and altitude, transmission potential of same species of vector varies accordingly in different ecological setting of Nepal. Detail is documented in the paper in Annex 5. Combination of ecological zone, land-use characteristics and presence of malaria cases were analyzed in GIS environment, to derive entomological risk of malaria transmission.



Map 2. Entomological risk of malaria transmission (Ecology)

Plain outer Terai VDCs were subdivided into two categories, forest ecosystem (high transmission potential) and cultivated areas (low transmission potential) based on land-use 2010. Inner Terai came as high and moderate transmission potential and the remaining three ecological zones came under low transmission potential. Altogether 97(2.44%) VDCs came under high transmission potential category. Similarly, 206(5.18%) VDCs came under moderate transmission potential VDCs and 3665 (92.18%) came under low transmission potential. Risk couldn't be determined for 8 VDCs due to missing parameters. The output is refined in Inner Terai as there is already evidence of high number of cases in some areas of inner Terai. So, inner Terai is subdivided into two categories: firstly, VDCs with cases in all the last three years (high transmission potential) and secondly, other VDCs with cases in any of the years only (moderate transmission potential). In this way, 23(1.17%) VDCs in inner Terai moved from moderate to high transmission potential. The entomological risk of malaria transmission is shown in Map 2. According to scoring criteria, VDCs with high transmission potential received 1. Likewise, moderate burden VDCs received response value 0.6 and low burden VDCs received 0.1. The weight a VDC got based on ecology was 0.5.

8.3. Vulnerability



Map 3. Vulnerability due to population movement

The third determinant, vulnerability is measured in terms of population movement. If VDCs report regular movement to forest (with overnight stay), has ongoing development projects or

resettlement activities, those are assigned to high vulnerability category. VDCs report movement to high risk states of India and high risk VDCs of the country are assigned to moderate vulnerability category. VDCs report movement to endemic areas of the country as well as other countries and limited movement to forest are assigned to low vulnerability. Movements to non-endemic areas were classified as no risk. As a result, 686 (17.25%) VDCs came under high vulnerability and 3290 (82.75%) VDCs came under low vulnerability. None of the VDCs came to moderate vulnerability. All the VDCs reported one or other kind of movements. There is not a single VDCs came under no vulnerability. According to scoring criteria, VDCs with high vulnerability received 1. Likewise, VDCs moderate vulnerability received response value 0.6 and low vulnerability VDCs received 0.1. Weight a VDC got based on ecology was 0.2.

8.4. Overall risk

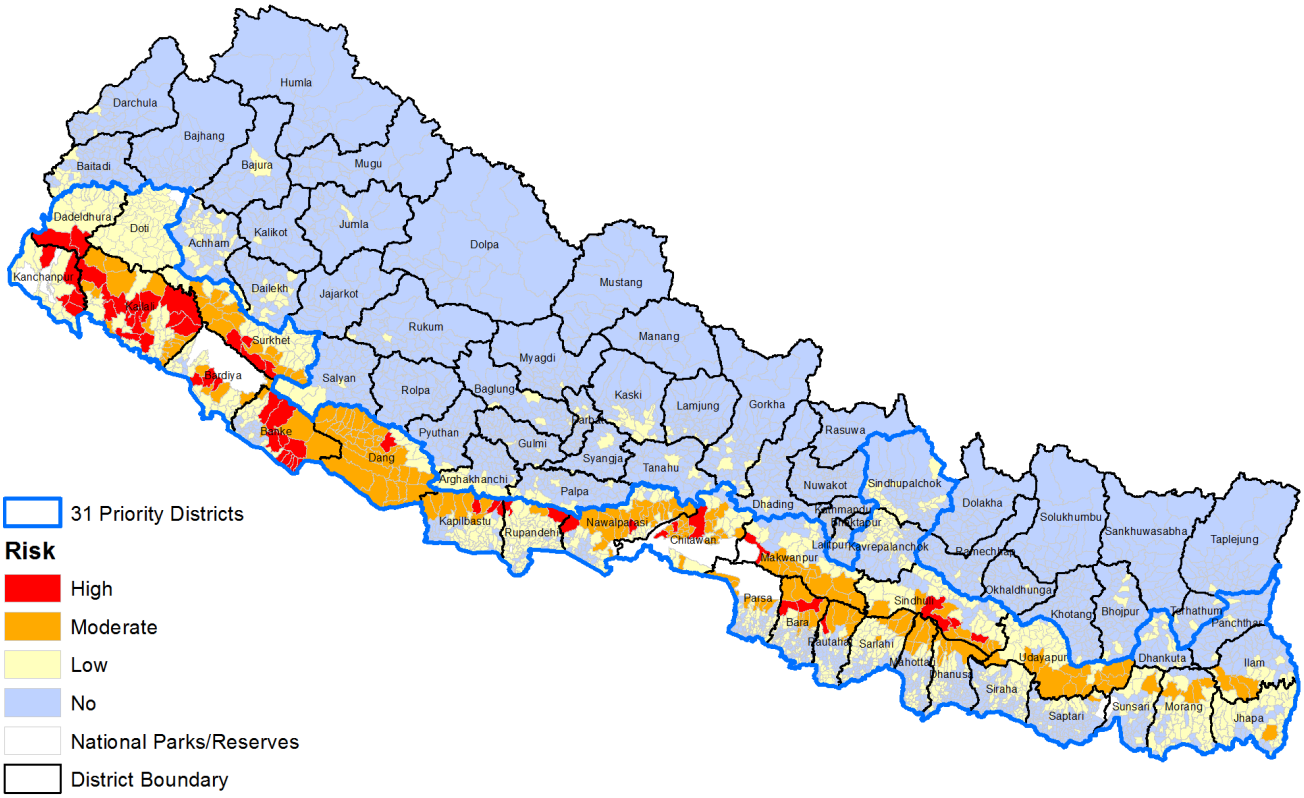
Based on scoring **(Disease burden with weight 0.3, Ecology with weight 0.5, and Vulnerability wih weight 0.2)**, 54(1.35%) VDCs came under high risk category, 201(5.06%) VDCs came under moderate risk category, 999(25.13%) came under low risk cateogry and 2718(68.36%) came under no risk category. A total population of 985,636(3.62%) live in high risk VDCs, 2,660,692 (9.79%) live in moderate risk VDCs, and 9,378,735 (34.52%) live in low risk VDCs. A total population of 14,139,920(52.05%) live in no risk VDCs. District wise inforamtion on location risk VDCs and risk population is shown in Annexes 7 and 8.

Most of the high risk VDCs are seen in the Far-western (19 VDCs) followed by Mid-western region (18 VDCs). Central and Western regions have 10 and 7 VDCs under high risk respectively where as there are no high risk VDCs in the Eastern region.Altogather, 77 VDCs of the Central region came under moderate risk, followed by the Mid-western (59 VDCs), Western (27 VDCs), Eastern (24VDCs) and the rest (14 VDCs) from the Far-western regions. A total of 353 VDCs of the Central region followed by the Eastern (215 VDCs), Western (191 VDCS), Far-western (148 VDCS) and Mid-western (92 VDCs) regions were classified under low risk. Most of the no risk VDCs (778 VDCs) came from the Central region, followed by the Eastern region (668 VDCs) and the Western (652), Mid-Western(region (412 VDCs), and the Far-Western(208 VDCs) regions. Detail information on risk VDCs and risk population by district is contained in Annex 7.

Table.3: VDCs and risk population by development regions in Nepal

Region	Number of districts	High Risk		Moderate Risk		Low Risk		No Risk		Total VDC	
		VDC	Population[1]	VDC	Population[1]	VDC	Population[1]	VDC	Population[1]	VDC	Population[1]
Eastern	**16**			**24**	**430773**	**215**	**2511297**	**668**	**3235282**	**909**	**6177352**
Central	**19**	**10**	**258959**	**77**	**927902**	**353**	**2821865**	**778**	**5675767**	**1218**	**9684493**
Western	**16**	**7**	**115595**	**27**	**372822**	**191**	**1881278**	**652**	**2661812**	**877**	**5031507**
Mid-Western[2]	**15**	**18**	**246740**	**59**	**692140**	**92**	**883228**	**412**	**1767651**	**583**	**3589759**
Far-Western	**9**	**19**	**364342**	**14**	**237055**	**148**	**1281067**	**208**	**799408**	**389**	**2681872**
Grand Total[2]	**75**	**54**	**985636**	**201**	**2660692**	**999**	**9378735**	**2718**	**14139920**	**3976**	**27164983**

[1]-VDC population is supplied by DPHO/DHO or else, taken from Census 2011, CBS. [2] - VDC with missing population is not included in the analysis.



Map 4: VDC level malaria risk in Nepal

9. Limitations

- There exists a large imbalance between the confirmed cases and the clinical cases. The current stratification is based on API of the confirmed cases only. The study does not take into account clinical cases, so excluding clinical cases may have underestimated the malaria risk.
- Case investigation and classification of cases were not done at least in a sample of cases in each VDC to help determine the presence of local transmission in each VDC.
- Among the confirmed cases also, there is no standard operating procedure (SoPs) established to classify case (i.e., indigenous cases vs imported cases). There is no way to track the origin of case.
- Routine reporting systems often do not include cases from private facilities and government hospitals, so disease trends in health facilities may not reflect the entire population.
- The entomological information is not up to date. There is no current study conducted in entomology. Over the years, there are so much ecological changes and high usage of

insecticides that might have led to changes in vector bionomics. The analysis is based on historical evidences only.

- There are no base line entomological studies of the Himalayan mountain districts and it is presumed that there are no malaria vectors present in the region due to the climatological factors and historically no evidence of malaria transmission.
- In the context of Nepal, there is a large variation in topography and ecology in many of the VDCs. VDC, being unit of study, may have generalized these variations. Stratification is by VDC which comprises of several wards and villages. In some VDCs, various ecological types exist thus the risk of malaria vary within the VDC.
- Reports from 44 high hill and mountain districts are scanty and erratic. Reports show very few malaria cases of indigenous transmission, however, both indigenous and majority imported malaria cases require verification for classification.

10. Conclusion and Recommendation:

In Nepal, previous malaria micro-stratifications were limited to district level. The current micro-stratification provided the insight of malaria risk at VDC level. This will help the Malaria Elimination Programme to target interventions at VDCs level. The programme needs to address the limitations mentioned above, by adopting the recommendation listed below to further refine the current stratification result and hence to identify the risk areas at ward level and even to village level.

- The following may be done in preparation to update and refine the risk stratification (within 2 and every 3 years thereafter):

    1. Validate the risk stratification
    2. Surveillance should be geared up according to the WHO revised guideline for malaria elimination.
    3. All cases should be onfirmed either by microscopy or RDT
    4. Establish computerized database of every case; with link to GIS map
    5. Cases should be recorded by ward or village
    6. All positive cases should be investigated and classified; geo-reference of the case should be recorded using GPS
    7. Update the entomological information
        - study on vector bionomics (in selected ecotypes in east, mid-west, and far-west)
        - entomological surveys in as many VDC as possible with different ecotype

- Suggestions to validate the risk stratification within two years

1. Five VDC from each risk category to be selected randomly
2. Key activities
    - Malariometric survey
    - Serological survey
    - Entomological survey
    - Geographical reconnaissance, including the use of GPS
    - Mapping of cases by ward or village
    - KAP survey

- Finally, based on the present micro-stratification following prevention and control interventions can be deployed:

Table 4. Recommended Interventions per Stratum

Interventions	High risk	Mod risk	Low risk	No Risk
LLINs	1st priority; limited to wards with indigenous cases and adjacent wards within 2 - 3 kms	2nd priority; limited to wards with indigenous cases adjacent wards within 2 - 3kms	3rd priority; limited to households with confirm cases only to prevent transmission	NA
IRS	Focal; 1 - 2 cycles depending on duration of transmission and residual efficacy of insecticide	Yes; to contain outbreak	Yes, to contain outbreak	NA
Larval control	as appropriate	as appropriate	as appropriate	NA
EDPT	Yes	Yes	Yes	Yes
Case investigation	Yes	Yes	Yes	Yes
Foci investigation	Yes, 2nd priority	Yes, first priority	No, except when indigenous case is reported	NA
BCC	Yes	Yes	Yes	Yes

11. Acknowledgement

WHRC would like to express its heart felt appreciation to the Director of the Epidemiology and Disease Control Division in believing in us to assign this important activity of Malaria

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12. Annexes

Annex 1. Questionnaire to collect VDC/municipality based basic malaria information

Annex 2 a. Guidelines for data collection

Annex 2 b. ToRs for Regional Team

Annex 3 a. VDC wise consolidated data form

Annex 3b. VDC wise consolidated malaria profile

Annex 3c. IRS Coverage

Annex 3d. LLIN Coverage

Annex 3e. Laboratory Services

Annex 4. Schema of MS Access database

Annex 5. Entomological Workshop

Annex6. Scientific Paper (Scoring methodology)

Annex 7. VDC wise malaria risk table

Annex 8. District-wise risk maps and tables

Annex 9a: District level malariometric indices

Annex 9b: District level malaria profile