UNIVERSITY OF NATURAL RESSOURCES AND LIFE SCIENCES, BOKU, VIENNA

Survey report of a selected pilot site for development of a micro watershed management model for the EUCCR-PNG project (D 2)

Survey report of a pilot site "Vaya Community, Kome LLG, Menyamya District" for the project "Strengthening food production capacity and the resilience to drought of vulnerable communities"

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Assessment report for the selection process of a pilot site for the project "Strengthening food production capacity and the resilience to drought of vulnerable communities" on the participatory establishment of a micro-watershed management model in one of the target sites that assists in enhancing water capture and storage capacities of the target communities to augment irrigation and domestic water supply during dry periods and can serve as a model for outscaling through other interventions.

1. Background

This report is based on the listed tasks and deliverables given below and corresponds to the deliverable D 2:

T1. To conduct a pre-assessment based on secondary data and information of up to 11 pilot sites identified in the project. The assessment will assist in selecting up to three sites for a more detailed stock-staking exercise

T2. To develop criteria for selecting one pilot site for establishment of a micro-watershed

T3. To take lead in reconnaissance surveys of up to three potential sites for selection of the final pilot site

D1. Pre-assessment report on selection of three potential pilot sites

D2. Survey report of three potential pilot sites with recommendation on selected pilot site for micro watershed management model

Summary:

During the first visit to the selected project sites, the pre-assessment (T1 + T3) and a survey (T3 partly) was conducted to identify and preselect potential sites that can be selected as pilot micro-watershed. This selection process and the assessment/survey are documented in the "**Technical report on the watershed assessment for the EUCCR-PNG project**" (D1 + D2 partly).

Two sites were selected for detailed survey: **Vaya** & **Taita** village in Menyamya district, Kome LLG.

Based on lessons-learned from previous project activities and community-based interventions it was decided to focus on one project site for the detailed watershed survey and watershed delineation. This mainly minimizes the negative effect of raised expectations of community members and adverse impacts on other project activities in case of non-selection of the other project sites. Therefore, it was decided to follow a three step (phase) procedure for the final site selection and detailed survey described in the following section 2.3. site selection and survey process.

Literature review (T4) is being done permanently

2. Site pre-assessment and pre-selection (T 1)

The site pre-assessment and pre-selection was made using following methods and criteria:

- FGD & Community discussion
- Transect walk
- Picture documentation
- Soil survey
- Village mapping
- Resource mapping

Selection Criteria:

- Available water source

- Potential for water source development and use of different technologies for upscaling
- Vulnerability to climate change induced risks
- Accessibility of the site
- Priorities of community
- Understanding of and importance of protection of ecosystems and watershed
- Common understand of watershed management and livelihood within the community
- No potential and obvious reasons for dispute within and with neighboring the communities
- Existing formal or informal water bylaws

The results from the site pre-assessment and pre-selection process is described and summarized in the **"Technical report on the watershed assessment" (D 1)**.

3. Final site selection and reconnaissance survey process

3.1. Phase 1: Selection Criteria and Site selection (T 2)

(Continuation from assessment/survey done during first site visits)

Selection Criteria

- A small watershed or micro-watershed with significant natural assets, especially water,
- Micro-watershed with the potential to leverage inherent economic incentives to collaborate across garden lines around water or other shared local resources,
- Geographically well-defined sites of manageable scale where stakeholders live in close proximity and have economic incentives to collaborate.

Site selection criteria include environmental, socio-economic and vulnerability factors.

Environmental Criteria: the presence of factors that foster sustainable land use such as agroforestry, especially on slopes, and sustainable agricultural intensification, also natural ecosystem services:

- Average annual rainfall
- Water resources
- Existing tree cover
- Per capita cultivated land
- Presence of environmentally protected areas, or natural areas providing important ecosystem services.

Socio-economic Criteria: factors that indicate an enabling environment for sustainable water and land use:

- Infrastructure, including downstream investments (roads, irrigation systems, markets)
- Social capital, both current and prospective
- Sustainable agro-economic / climate-smart value chains and livelihood activities

Vulnerability Criteria: environmental risk due to the effects of deforestation and agricultural activities, soil erosion risk, including on steep slopes

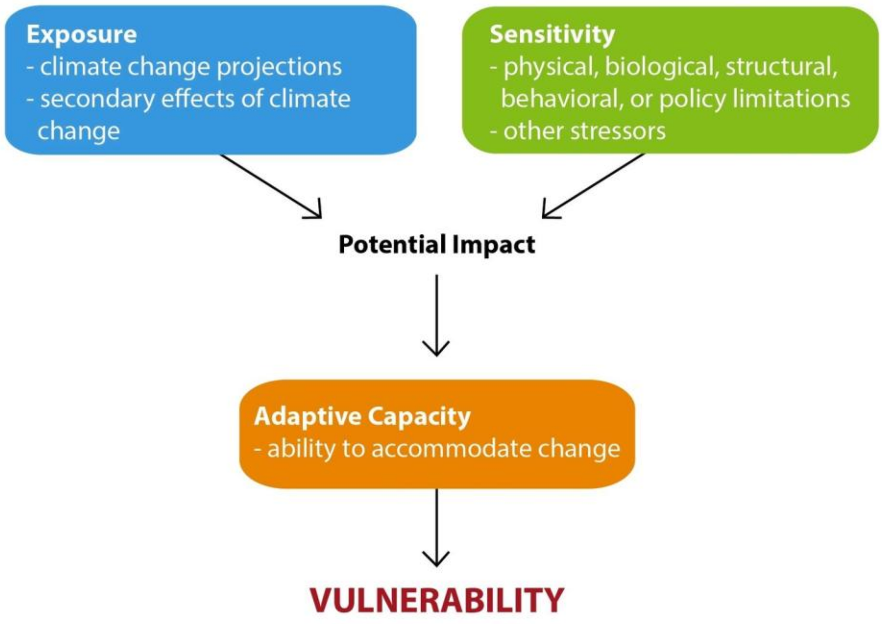

Fig. 1: Relationship between vulnerability, exposure, sensitivity, and adaptive capacity

Keywords: Type of water source, climatic condition, vulnerability to climate change, food security, agricultural activity including experience with irrigation, willingness and openness of the community to collaborate, importance of protection of ecosystem and watershed, slope classes, soil type, SWOT

3.2. Phase 2: Participatory watershed survey (T 3)

The survey and delineation of the watershed was conducted as a participatory learning process.

- FGDs, participatory stakeholder and resource mapping, needs assessment, problem tree analysis, assets, local knowledge
- Transect walk, biophysical data collection (water, soil, topography, fallback option, ecosystem, CC indicators, GPS/GIS reconnaissance survey (land and water))
- Transect walks and village mapping
- Soil mapping
- Identify locations of homesteads, fishponds, food gardens, areas used for cultivation and/or recovery during periods of drought
- Recording of flow rates of springs and streams
- Documentation of water use scenarios and land use practices during prolonged droughts
- Identify community fallback options during times of drought (water and food)
- Identify potential sites for retention ponds, water harvesting, ram pump, soil moisture conservation
- Installation of manual rain gauges& recording of rainfall
- Key Informant interviews, opportunistic interviews
- Livelihood assessment/SWOT analysis

Definition of livelihood assessment

A livelihood is a means of making a living. It encompasses people's capabilities, assets, income and activities required to secure the necessities of life. A livelihood is sustainable when it enables people to cope with and recover from shocks and stresses (such as natural disasters and economic or social upheavals) and enhance their well-being and that of future generations without undermining the natural environment or resource base.

A sustainable livelihood is defined by the UN Economic and Social Commission for Asia and the Pacific (UN-ESCAP) as having "the ability to cope and recover from unexpected events, while at the same time enhancing current and future capabilities" (UN-ESCAP, 2008). This definition interlinks the definitions of resilience, sustainability, and livelihood, as each affects the others and highlights how DRR or mitigation strategies directly affect sustainable livelihood. This means that there needs to be a heavy focus on reducing vulnerabilities of the community, including reducing poverty levels, building capacities and coping mechanisms, and focusing on community resilience (UN-ESCAP, 2008). There are five primary assets or capitals in the sustainable livelihoods framework (figure 2) that can influence sustainability and community resilience, as they can all be affected during disasters. These assets are human, social, natural, physical, and financial capital.

The DFID defines a sustainable livelihood (SL) based on capabilities, assets (both material and social resources) and activities required for living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining natural resource bases.

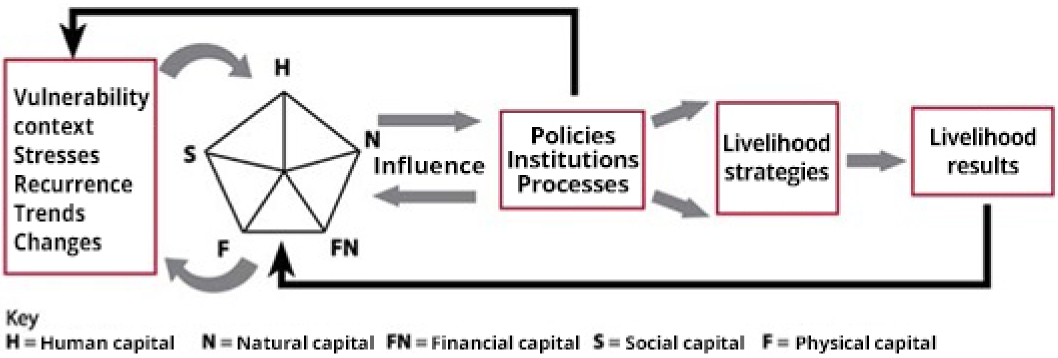

Fig. 2: Livelihood assessment (Source: DFID 2001)

Livelihoods can therefore be affected by external factors which increase their resilience and consequently reduce their vulnerability.

The survey was conducted applying above mentioned criteria, methods and tools:

Data Collection

- Compile and review activity reports of other relevant project activities
- Collection of GIS data and topographic maps
- Climatic data
- Procurement of material

List of material used for the site survey:

- Garmin GPS Map 64s
- Tape measure
- Spring capacity measurement: bucket, timber, hammer, nails, hand saw, stop watch
- Simple manual rain gauges (daily & monthly measurements): jerry can, plastic bottles, funnels, vegetable oil, cable tie, permanent marker, cutter

3.3. Phase 3: Identify priorities & activities for watershed management plan

- Link science and communities' priorities
- Discussion and ranking of proposed and identified activities with community
- Debriefing and meeting with project coordinator and staff at NARI HQ to finalize micro-watershed selection process and planning
- Develop watershed management model for protection of functioning ecosystems and enhancement of ecosystem services through Participatory and learning centered methods for development.
- Micro-watershed management model and scenario development (technological, bio-physical and social & livelihood dimension)

4. Delineation of the study site and results from the survey

4.1. Demographic data and livelihood assessment

Household Number	**Household name**	**Household members**	**Total**	**Gender**
1	Pelik	Pelik, Betty, Jonam, Limson	4	3M and 1F
2	Dickson	Dickson, Rahael, Emma, Dinah, Iso, Bita, Fralyn, Mesi,Malvin and a new born baby	10	4M and 6F
3	Issaca	Issaca, Termah, Sendrah, Anna, Rachael and Iseal	6	2M and 4F
4	Daniel	Daniel, Barbine, Saina, Greg, Max, Joyce, andPanlella	7	3M and 4F
5	Gibson	Gibson, Ismael, Giwising, Gersom, Brendah, Seroth, Gero, Rex, Gersoma, Hanliel, Lucy, Bethuel, Kennepy and Wareto	14	6M and 8F
6	Joe	Joe, Diane, Brain and Danny	4	3M and 1F
7	Simon	Simon, Solomon, Lydia, Rickson and Mapini	5	3M and 2F
8	Hendry	Hendry, Alice, Franky, Lemary, Flory, Dalson, Delma, Splendah, Herish, Jerry and Lonbill	11	7M and 4F
9	Nelson	Nelson, Wendy, Nelton, Nelphy, Metolyn, and Nimson	6	3M and 3F
10	Sipas	Sipas, Nelly and Narly	3	1M and 2F
11	Elmon	Elmon, Julie, Gonex, and Charles	4	3M and 1F
12	Martin	Martin, Judicah, and Mishelle	3	1M and 2F
13	Jonathan	Jonathan, Dorcas, Mispaa, Derithr, Jonish, Doris, Eslina and Flishwel	8	4M and 4F
14	Justin	Justin, Selina, Cecelina, Jeroth, Kelvin, Kelvina, Limat, Lenah, Mesia, Yapio, Janson, Jackson and a Baby	13	8M and 5F
15	George	George, Wenny, Akia, Agness, Alphonese, Jarison, Akna, and Elizabeth	8	4M and 4F
16	Dominik	Dominik, Sharon, Darish, Cerlyn and Fabian	5	2M and 3F
Total			**111**	**57M and 54F**

Tab.1: Demographic set-up of Vaya community

The Vaya community has a population of 111 people of which 54 are female and 57 are male. Community members live in 16 households located across the watershed. A summary of the demographic survey is presented in table 1. Most households are located in the upper part of the community land below the main road as shown in figure 3 (map C) and the watershed sketch (figure 4) that was drawn during a village mapping exercise in October 2018. Most of the households have to fetch water from the communities' main water source the Vaya creek spring, which is located close to the main road.

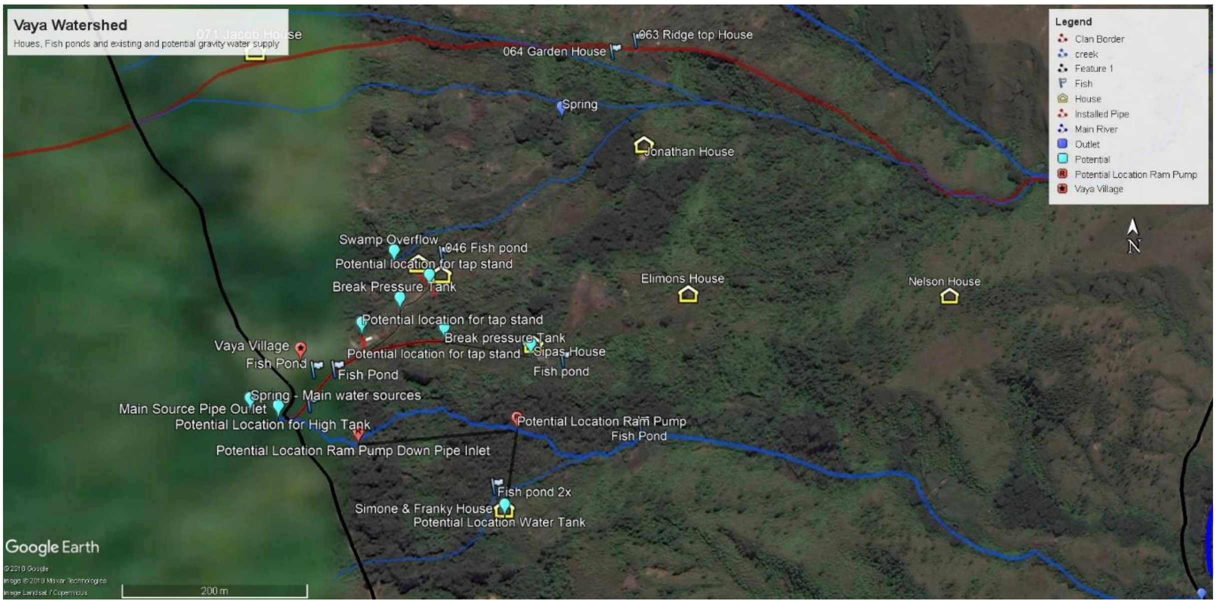

Fig. 3: Locations of homesteads across Vaya Watershed (Map C)

The majority of the people in the community are constrained by low incomes and moderate potential environments. There is some agricultural pressure, land potential is moderate to low and access to services is moderate.

Strength	Weakness
• Small and homogeneous community setting • Clear leadership structure • Sound ecological resource base (forest, soil, water) • Moderate diversity of livelihood options (coffee, vanilla, fish, …) • Diversified food and cash crop production • Perennial water source	• Moderately high sensitivity to sudden and extreme climate impacts/shocks in terms of food production • Unclear situation regarding leadership and future generational changes and impact on ecosystem protection and selected development priorities • Lower lying areas are dominated by kunai grass and piper (suitability as residential area and farm land) • Difficult market access (road, transport, distance to main markets e.g. Lae)
Opportunities	**Threats**
• Increase adaptive capacity through improved natural resource/watershed management and adaptation measures • Improve and further diversify livelihood options: NTFP, coffee, nuts, vegetable, fish • Stable and reliable water supply • Irrigation	• Population growth • Pressure on land for food production • Exposure to climate change impacts and shock events (El Nino) • Decreasing soil fertility through erosion • Shorter fallow periods

Tab. 2: Climate change impact SWOT analysis of Vaya community

Cash incomes are uniformly very low and are mainly earned from the sale of coffee and fresh food. Poor access and low potential environments are major constraints to improving incomes. People have to travel for up to eight hours to reach the biggest market in Lae.

The SWOT analysis displayed in table 2 shows that the communities' exposure and sensitivity to climate change extremes is the main weakness, which clearly defines their vulnerability against those impacts. However, the well protected watershed and ecosystem providing important and sustainable services to the community is their biggest asset and main driver and opportunity to increase the adaptive capacity and in turn reduce their vulnerability against climate change induced impacts. Even though the watershed seems to be well protected under the leadership of the old chief Solomon Martin and his by-laws future developments remain unclear. The old chief still seems to have the respect of the younger generation and his legacy regarding protection of forest across the community land and the spring catchment is well-respected. However different interests among community members and population growth and pressure on land for food production and cash crops might jeopardize the fragile balance between ecosystem protection and economic interests to increase financial capital. Inflow of financial capital through increased and intensive cultivation of cash crops such as coffee is one option to influence sustainability and community resilience which affected the communities' livelihood during disasters and adaptive capacity to long-term impacts due to climate change. A micro watershed management plan developed through a participatory process can provide guidance for the community to understand the linkages between protection of their social, natural and physical assets and increasing their income. Both go hand in hand and it is essential to keep the utilization of ecosystem services and natural resources and its protection well balanced.

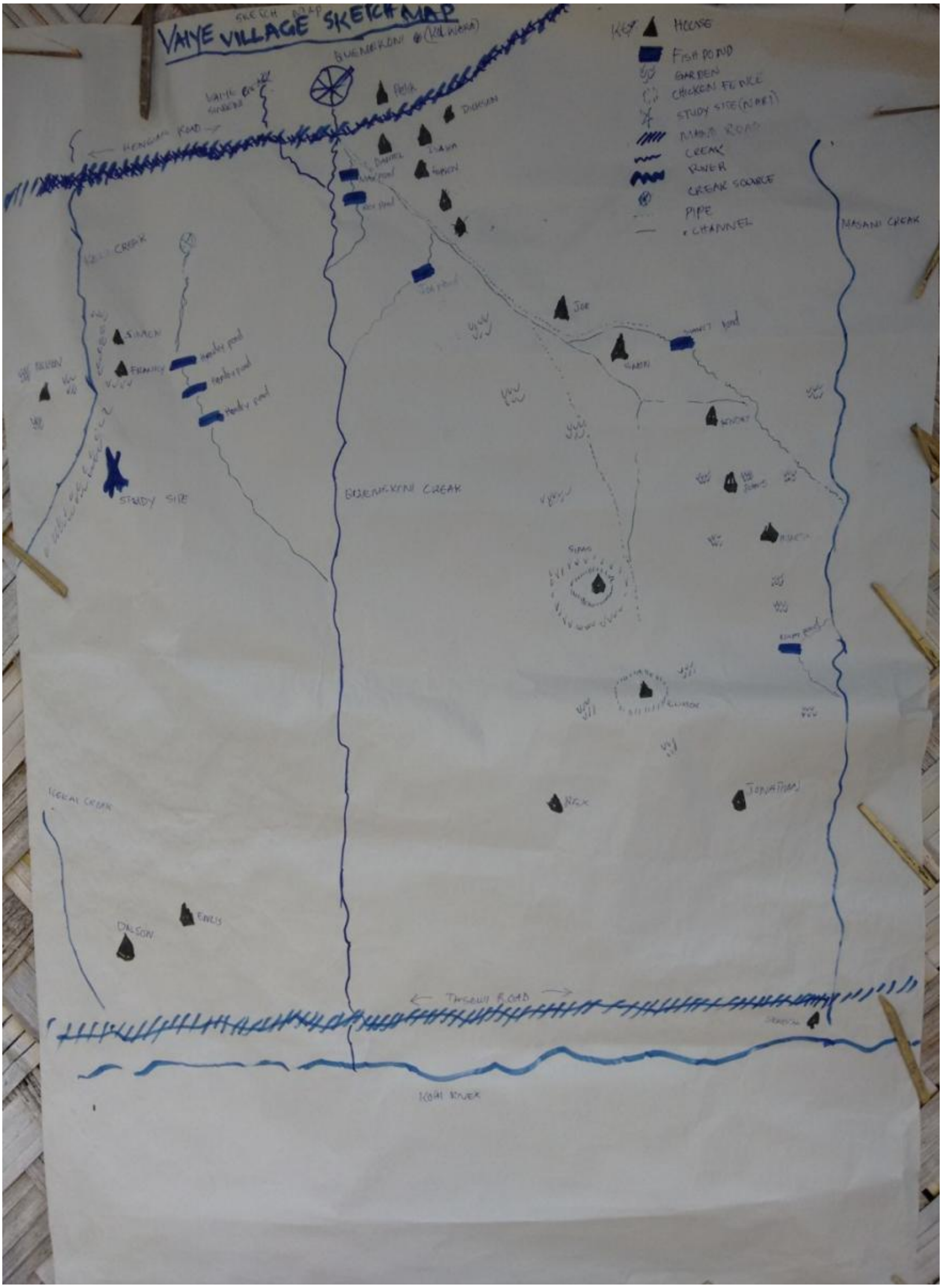

Fig. 4: Sketch of Vaya watershed from village mapping exercise (October 2018)

4.2. Bio-physical environment and watershed delineation

4.2.1. Watershed delineation

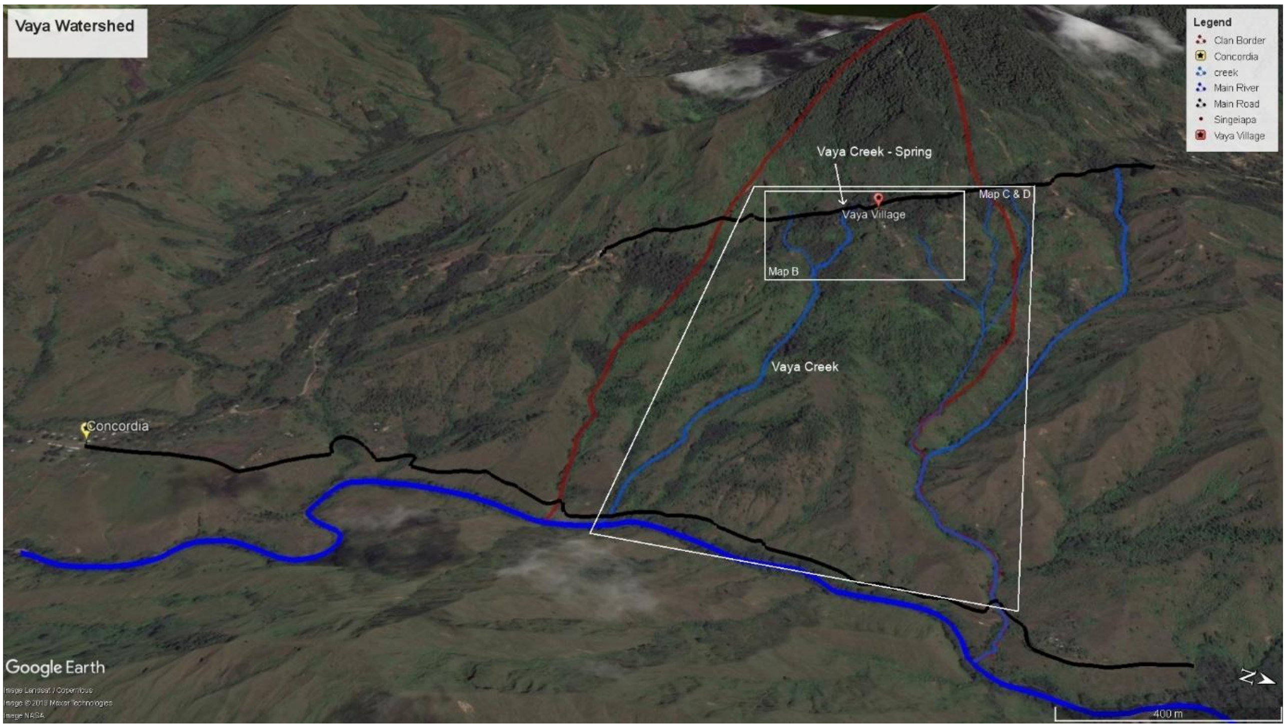

Fig. 5: Satellite Image of delineated Vaya Watershed (map A)

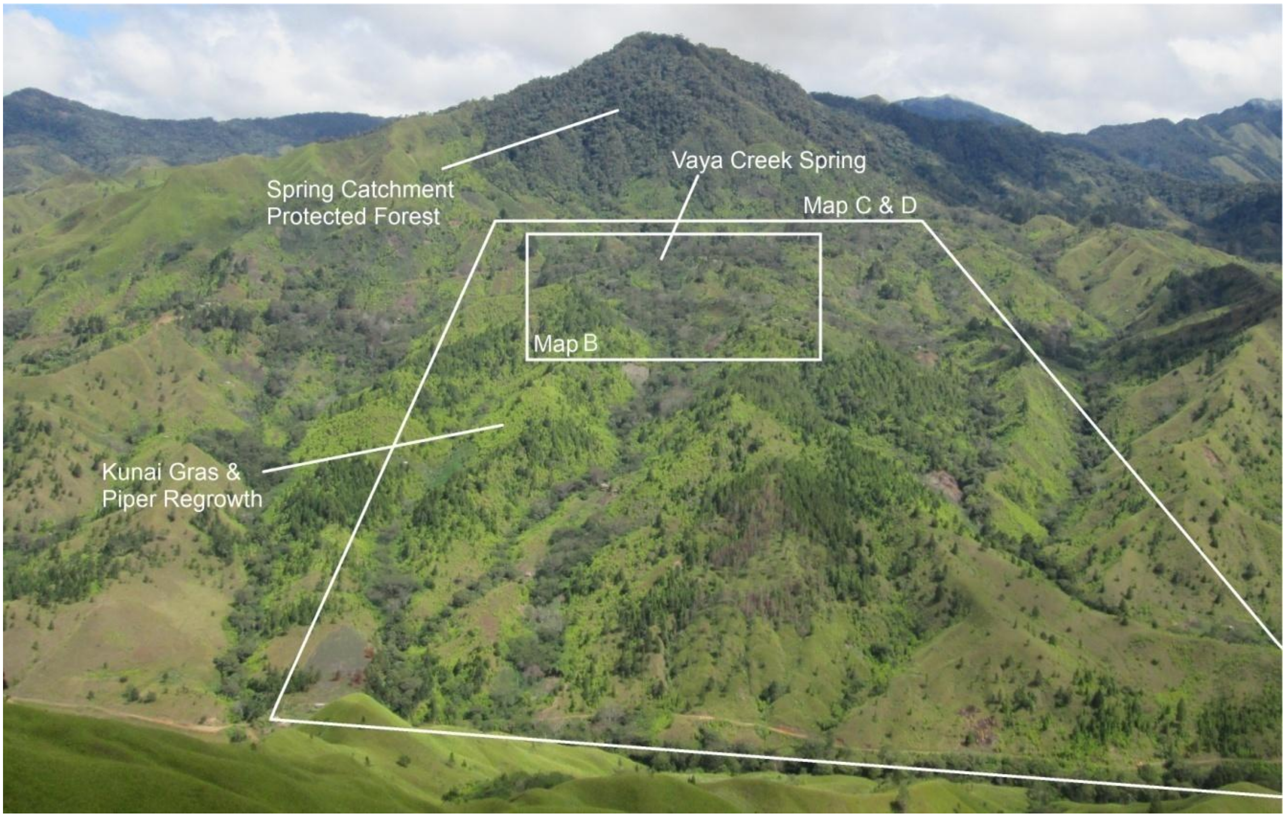

Fig. 6: Image of Vaya Watershed (July 2019)

4.2.2. Topography and Landform

The community is situated on a steep sided and densely forested mountain side. The size of the watershed and community land is 183 ha as marked with the red boarder line in figure 5 (map A).

Mainly the upper part of the watershed is covered by dense and native forest. The area has been overhunted by the younger generation, which probably led to an increased need for fish pond farming and village chicken farming. Orally passed on by-laws were developed which protect the surrounding bush land, food garden areas, fish pond areas, drainage systems and water piping systems through a non-burning policy. Therefore, slash & burn is not practiced in this watershed. Some knowledge on environmental protection was gain by the leader from government officers during in the 1960-70's.

The residential and farming areas are situated in the middle part of the watershed. Agro-forestry such as coffee production and farm land for crop production is predominating. The lower part of the catchment is dominated by kunai grass and piper with fewer agricultural activities. The entire landform is categorized as mountains and hills with weak or no structural control. The soil parent materials along the study sites are formed from shale, volcanically derived greywacke and siltstone. Minor conglomerate such as shelf facies are present.

4.2.3. Climate and climate change

The total annual rainfall values of Menyamya district range from 2079 to 2710mm in the south to 2711 to 2979 in the north, keeping it at moderated to low profile. Future climatic projections show that annual rainfall will increase and extend to the south of the district. Values for total rainfall on wet days show a district with moderate values but projections for the future show that these will increase throughout the whole district (Antea, 2017).

Drought risk is higher in the lower quarter of the district, with values that range from 24.1 to 29 continuous dry days, in comparison to the 21.1 to 24 of the other three quarters more to the north of the district. Projections for the future show that this dryness will increase and extend to the north in the near future (Antea, 2017).

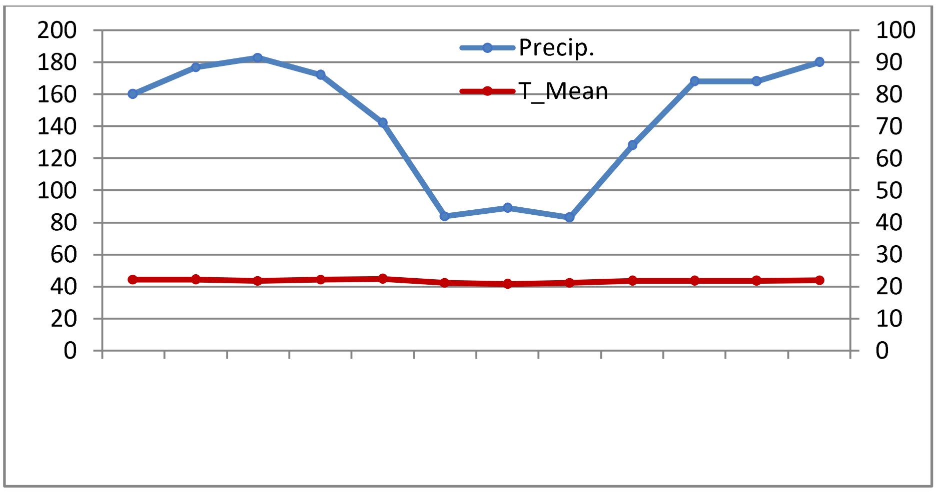

Fig. 7: Mean monthly temperature and precipitation of Menyamya (FAO LocClim data)

Meteorological data sets extracted from the FAO LocClim database displayed in figure 7 show mean monthly rainfall values ranging from 83 mm (August) to 183 mm (March) with one distinct dry season from June to August. Mean monthly temperatures remain constant throughout the year ranging between 20 and 22°C. Temperatures reach reaches the mean maximum values during the day of approximately 27°C and the mean minimum during night time of approximately 16°C. Potential evapotranspiration (PET) rates reach the highest mean value in December with 193 mm and the lowest mean value in June with 126 mm. The mean PET values correspond to the variation of mean day time temperatures, which are slightly higher in December (28°C) and the lowest in June and July (26°C).

4.2.3. Soil

According to PNGRIS the soil found in the area is classified as Ustropept. Ustropepts soils are under the soil order of Inceptisoils and suborder of Tropepts. It is a fine textured soil with A-B-C horizon. The A1 horizon is 10 to 30 cm with black, dark brown or dark reddish brown color and, when dry, has a hard to very hard consistency. It is a relatively shallow soil rich in base which limits to arable cropping and potentials for some tree crops and pasture (Bleeker, 1983).
The other soil identified within the project site is classified as Ustorthens soils which comes under the soil order of Entisols and suborder of Orthents also described as a colluvial soil. Colluvial soils are loose, unconsolidated sediments that have been deposited at the base of hillslopes by either rainwash, sheetwash, slow continuous downslope creep, or a variable combination of these processes. This term is also used to specifically refer to sediment deposited at the base of a hillslope by unconcentrated surface runoff or sheet erosion. Ustorthens are typically found on erosional surface and has either heavily truncated profiles or bare rocks at very shallow depth (Bleeker, 1983). The slope form can be described as convex-convex.

In the context of soil physical features and the morphology of the area such as steep slopes and high water run-off, the incidence of soil erosion is certainly prevalent, especially on plots which are under cultivation. In many gardens prepared on steep slopes the dark black top soil is already eroded and light sub soil with low organic matter content and subsequently lower productivity becomes visible.

The results from a soil survey conducted by a NARI survey team at Vaya shows that the soils have generally low pH values raging from 4,7 to 5,5 and can be described as strongly acidic. Younger soils, such as the colluvial soils that are present in the selected watershed, typically have fewer acids and more bases. As these soils are leached and weathered over time, especially in high rainfall areas, they will become more acidic. Low soil Ph might negatively affect the mineral solubility and hence availability of nutrients and generally lower the soils productivity level. Furthermore the results show generally low soil fertility status and low organic matter content which can be attributed to often interrelated factors. These include the parent material, particle size, humus content, pH, water content, aeration, temperature, root-surface area, and mycorrhizal development and of course cultivation practices. The results also show that soils which are under a prolonged period of fallow have slightly higher nutrient levels (especially K and P). This can be an indication of the positive impact of fallow on the nutrients status of the soils, which can provide a good scope for the introduction of improved fallow systems to build up soil organic matter and soil nutrients.

4.2.4. Water and water usage & supply

The mountainside is well watered by three permanent water sources, two of which reportedly may dry up at 2-3 years intervals, most likely associated with lower seasonal rainfall. One water source is a swamp overflow sourcing the Emanga creek. One central spring-water source, which is the origin of Vaya creek, is consistent throughout the year and supplies a large number of households and different purposes – including fish ponds, household use, some irrigation and water supply to lower valley communities. During times of drought also surrounding communities come to this source to fetch water. The spring water is not collected with a constructed spring catchment system, but flows freely in an open channel and consequently forms the run-off of Vaya creek. Two poly pipes are installed to supply water to homesteads (figure 8). Pipe 2 as shown in figure 8 is used to supplies water to a group of houses. Pipe 1 was initially installed to supply water to a camp set-up for a church meeting. The pipe ends in an area covered by shrubs. The poly pipes are just placed in the open water stream. No storage tanks, tap stands or control valves are installed and the water flows uncontrolled and continuously. An open channel system diverts water to fish ponds and was also used to divert water to food gardens to water crops during dry seasons. Currently the channels are not used to practice irrigation.

A bamboo pipe as shown in figure 9 is installed downstream of the spring to divert water for easy access. Flow rate however is very low.

The Vaya spring-water catchment is well protected under the leadership of the patriarchal clan leader Solomon Martin.

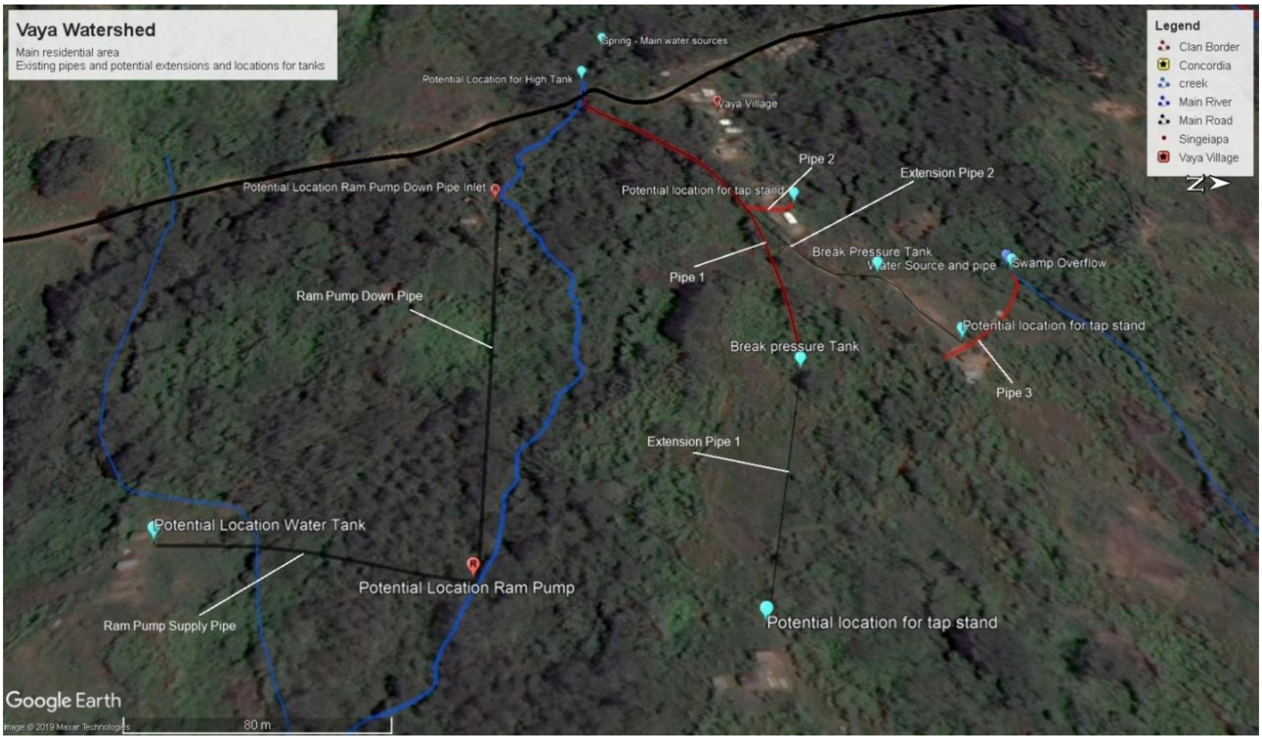

Fig: 8: Existing (red) and proposed (black) water supply at Vaya watershed (map B)

Bamboo Pipe and free run-off at Vaya creek spring (main source). The spring is located a few meters upstream behind the bush and very close to the main road.

Pipe 1 and 2 nearby main inlet & sources. This location is just a few meters below the main road.

Pipe 1 and 2 and earthen channel diversion to a fish pond

Fig. 9: Images across Vaya watershed

A water-resource-use mapping exercise was conducted, which provides a good inside in the watershed functionality and usage of existing water sources. The community is well spread over the hill side location and divided by a small deep valley which was formed by Vaya creek. This topographic set-up provides a realistic option to install ram pumps which can supply water to areas which do not have reliable perennial water supply. Quantitative measurements of the utilized spring and the catchment were done to assess the quantity of the available water for multiple uses in the watershed. The capacity of the Vaya creek spring is app. 100 l/min during moderate wet season. It is expected that the capacity of the spring might decrease during very dry periods. However, the spring catchment is large and the water potentially stored in the rock formations of the mountain might be big enough to continuously supply water to the spring without significant change of flow rate. The capacity of the spring was measured using a 10-liter bucket and a stop watch.

As displayed in figure 8 (map B) three poly pipes (red) were installed supplying water to three households. The black lines indicate potential extensions of the pipes and locations for tap stands. Location of break pressure tanks and storage tanks are also plotted. Detailed calculations of the gravity water supply system after a community led water supply planning exercise and decision-making process, will give exact locations for the tanks, gate and control valves, tap stands and dimensions of the poly pipes. During the community led process decision will be made which households and areas should be supplied with water and which scenario is financially and technically feasible. An important issue that has to be addressed is the polluted and nutrient rich effluent from the fish ponds which is diverted into the creeks draining the watershed. This is mainly crucial if the water is also used for domestic purposes.

The elevation profiles for pipe 1, 2 and 3 and suggested extensions of these pipes are given in the figures 10, 11 & 12 below.

Vaya creek and the topographic set-up of the area provide good scope to install a ram pump to supply water to the southern part of the community area. A possible location for the ram pump, down pipe and delivery/supply pipe is plotted in figure 8 (map B). The elevation profile of the down pipe supplying water to the ram pump and the delivery pipe are given in figures 13. The delivery height for the ram pump for the suggested location is app. 8m.

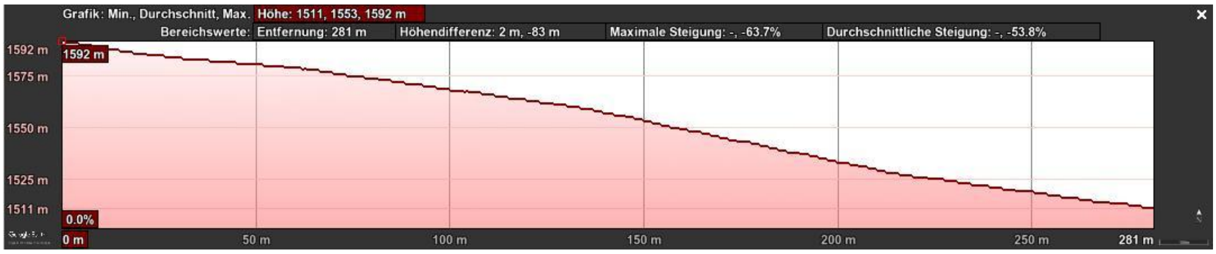

Fig: 10: Elevation profile of existing pipe 1 (above) and proposed extension of pipe 1 (below)

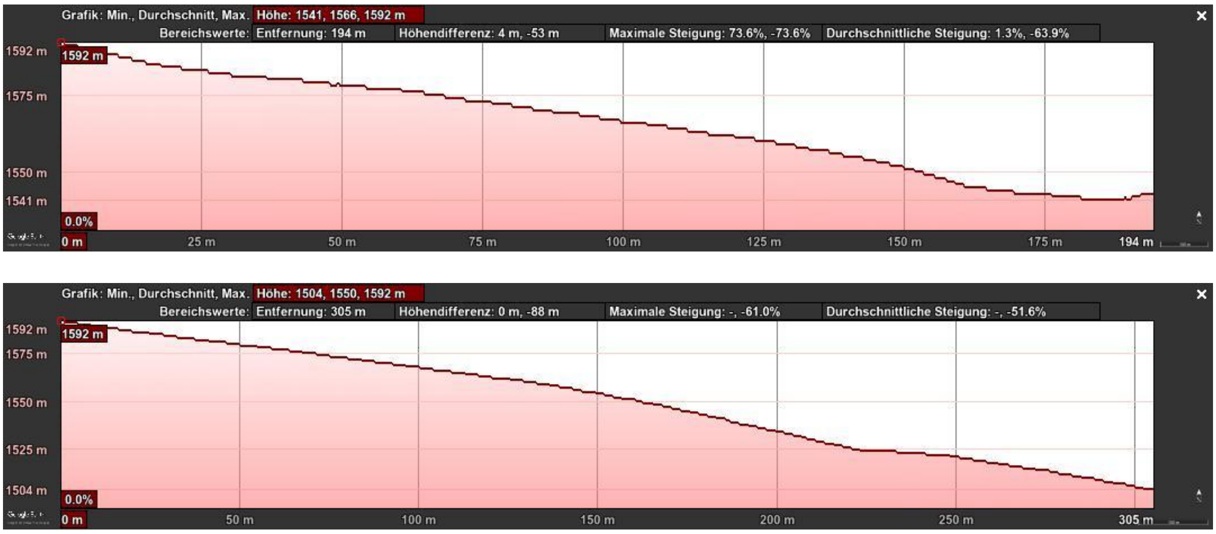

Fig: 11: Elevation profile of existing pipe 2 (above) and proposed extension of pipe 2 (below)

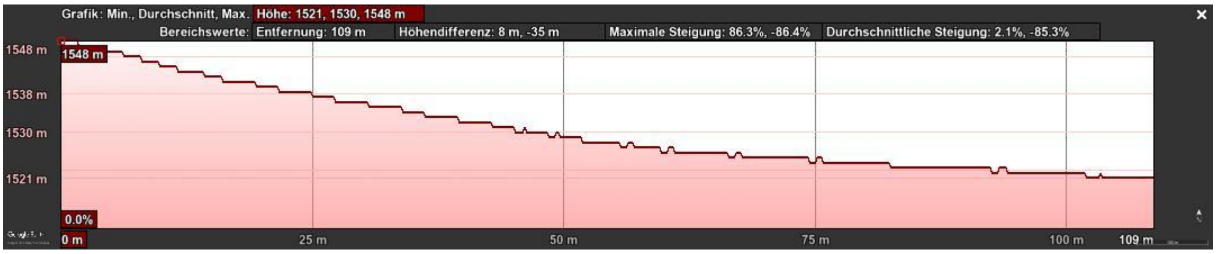

Fig: 12: Elevation profile of existing pipe 3

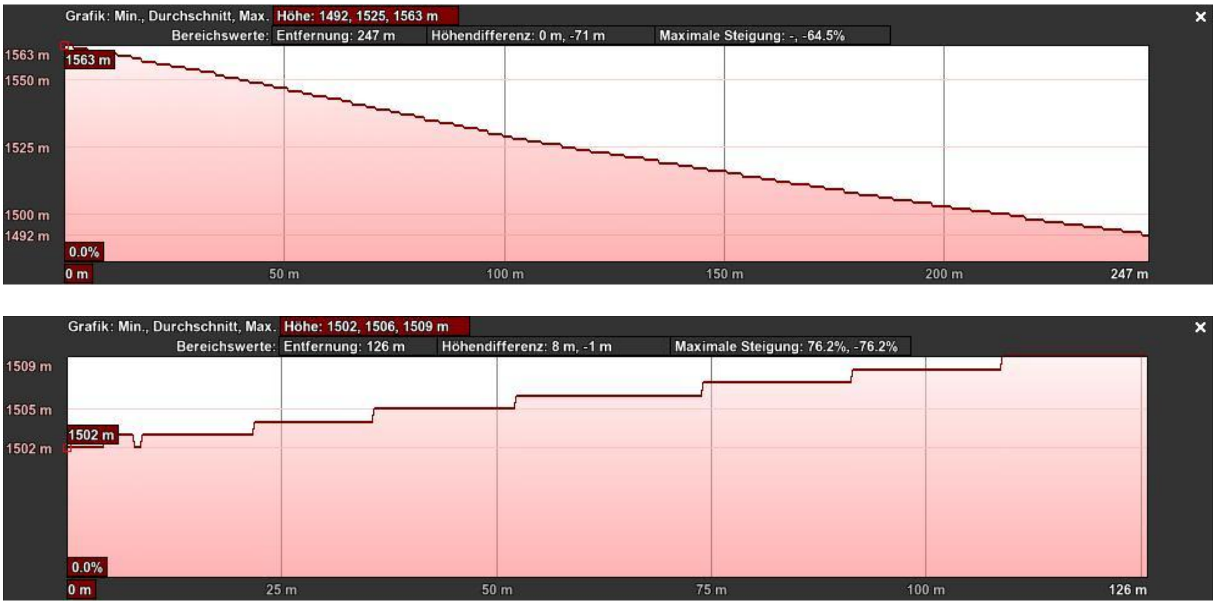

Fig: 13: Elevation profile of proposed down pipe (above) and delivery/supply pipe (below) for ram pump

4.2.5. Vegetation and Agriculture activities

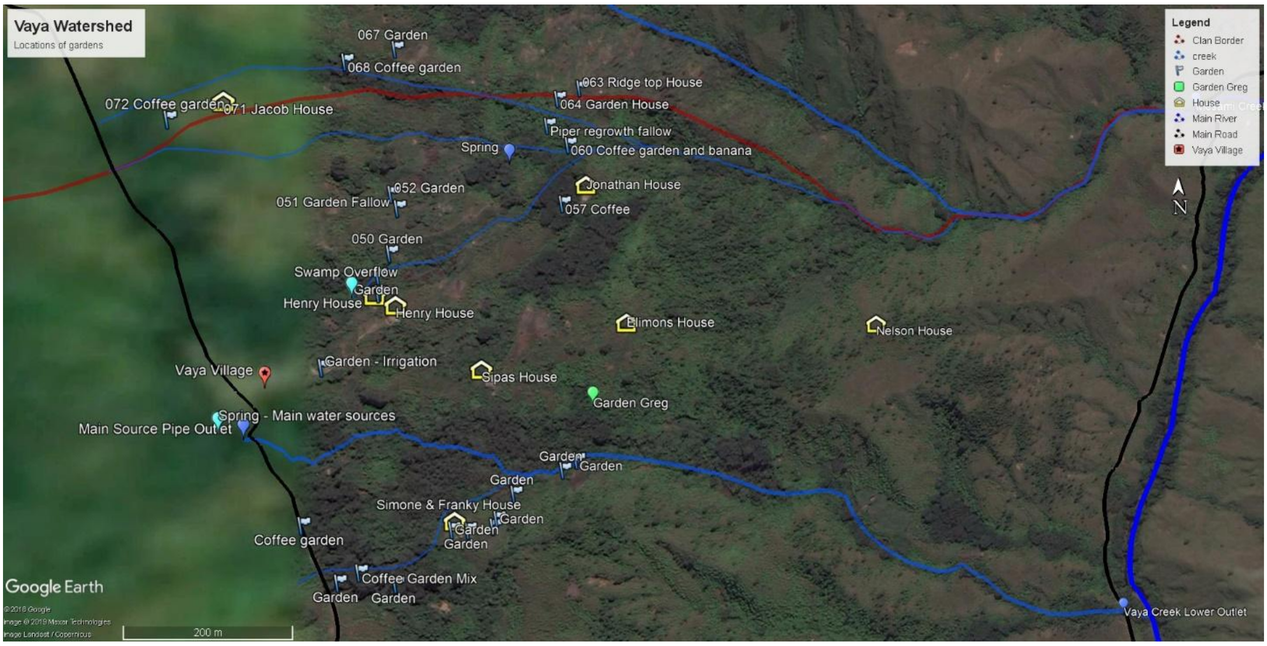

Fig. 14: Locations of homesteads and gardens across Vaya community (map D)

Cultivation Practices

Slash & burn is commonly done with deep spot tillage for sweet potato planting on areas with a high slope gradient. Sweet potato mounds are made on moderate to flat areas

Based on observation, cultivation is mainly done on moderate sloped areas while steep areas are mainly covered by piper, kunai grass and pines trees. Farmers mentioned that length of fallow periods range from 1 to 2 years. Occasionally, cultivation on steep slopes can be observed and also gardens prepared encroaching into the upper parts of the catchment where native dense forest is still intact. This can be an indicator that farmers have to move to marginal land due to population pressure and lower availability of land.

Cropping system

Mix cropping is mainly practiced with short term crops like corn, beans, tomato, pumpkin, cabbages and local vegetables mixed with banana, cassava, sweet potato, yam, taro, pineapple, sugarcane, highlands and lowlands pit pit.

Peanut cultivation is practiced as mono-cropping for 1 to 3 seasons in the same gardens. Farmers mentioned that the second season of peanut gives higher yield compared to the initial season. This can be a good indicator for nitrogen fixation happening in the soil due to cultivation of peanuts.

Pawpaw, citrus and tamarillo fruit trees grow in between coffee gardens and around the houses

Coffee gardens are located along riversides under Leucaena leucocephala and Albizia lebbeck shade trees mixed with vanilla, red bandannas, taro and local bananas.

Cash crops

Coffee is the major cash crop and source of income in Vaya watershed. Coffee gardens integrated with banana and vanilla can be found alongside main perennial water sources and seasonal creeks.

Peanut is an additional cash crop and is cultivated in all the family gardens.

Livestock

Almost every household practices local poultry and piggery farming.

Fish

A moderate number of fish ponds are located throughout the slopes and valleys. The fish pond system is not overly complex and is of good construction although some ponds have water seepage problems which potentially damages coffee crops which surround them.

Trees and shrubs

Most common tree and shrub species in the area are pines tree, Albizia lebbeck, Leucaena leucocephala, Piper aduncum, Tithonia and Tephrosia. Farmers also mentioned that gardens which are cultivated after piper fallow give better yield. Piper top biomass has high potassium content which can encourage sweet potato tuberization and yield.

Irrigation

Community members mentioned that irrigation is practiced as required according to weather conditions. For this purpose, earthen channels were dug to divert the water from Vaya creek to the fish ponds and to some food gardens in the upper part of the watershed (map D, figure 14). During the transect walk a number of silted up nonfunctional channels were identified. Those channels were used to convey water to various parts of the cultivated land. The reason for the discontinued use of the channels could not be determined. The channels which supply water to the fish ponds in vicinity of the main water source however are functional and in use. This is however a clear indication that some sort of flood irrigation was practiced during very dry periods, which provides a good scope for irrigation interventions. The introduction of higher value crops like vegetables can be a good entry point to promote irrigation and increase the capacity of farmers to use irrigation as a measure to reduce climate change related impacts on food security.

Although there is less need of irrigation in the upper parts of the watershed there is recognition of the need for irrigation in food gardens of communities in the lower parts, which are mainly kunai grass areas. Gardens which are located a closer to creeks, are suitable areas for such interventions.

Depending on the irrigation technology (flood or drip irrigation) used, climatic conditions and crops cultivated the crop water requirements will vary. Based on the needs and priorities of the community detailed calculation for irrigation system planning and scheduling will be done.

Fig. 15: Image of plot where flood irrigation is practiced during drought

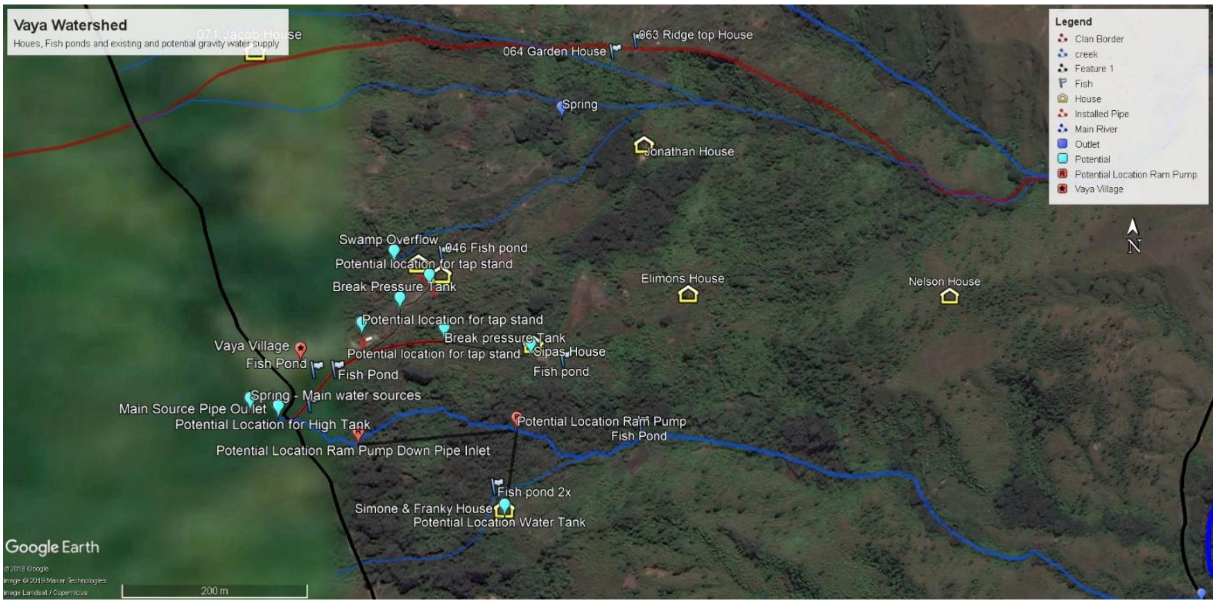

Fig. 16: Locations of homesteads and fish ponds across Vaya community (map C)

5. Conclusion and Recommendations

Problems identified:

- Drinking and soil water scarcity (drinking & irrigation) during drought events
- Low agricultural productivity
- Soil erosion on moderate to steep slopes
- Encroachment into forest land in the upper parts of the catchment
- Poor infrastructure facilities
- Undulated and fragmented land holding
- Lack of awareness & availability of improved seed varieties
- Definition of watershed management is not clearly understood. Hence a visual message dissemination medium like poster may give clear understanding of the context

Integration of agro-forestry systems and soil water protection measures have the potential to minimize water loss through evapotranspiration and water run-off during drought and eventually increase the water volume stored in the soil available for productive use.

Potential soil fertility and moisture conservation options are pineapple, highlands and lowlands pit pit hedge rows.

Tithonia, piper, tephrosia and Luciana are good options for improved fallow.

A detailed description of identified problems and potential measures are given in table 3.

Problem	Measure	Expected outcome
Soil erosion	Hedge rows (Pineapple), cover crops, and traditional terracing technique ('kekai')	Improved soil fertility and reduced soil loss
Fish pond effluent	Install effluent treatment ponds or filter system	Unpolluted water for downstream use
Drinking water scarcity	Improve water supply and introduce water purification technologies such as biosandfilter	Improved health and lower incidences of water related diseases Reduced water scarcity during prolonged dry seasons
Food and nutrition insecurity during dry season and El Niño	Food storage & processing, early maturing varieties, irrigation, seed and plant store in areas with high soil moisture content	Reduced food and nutrition insecurity
Soil water scarcity	Hedge rows (Pineapple) and traditional terracing technique ('kekai')	Increased crop productivity, faster recovery after drought events
Low soil fertility and low agricultural productivity	Improved fallow, crop demonstration with alternative and improved varieties, introduction of clean planting material and cleaning technologies, plot and crop	Higher agricultural productivity

	rotation to break reinfection cycle, vegetable nursery using green/shade net, vegetable seed store, drip irrigation	
Pressure on water source and protection forest	By-laws, identify and delineate protection areas	Improved protection of water resources and improved resilience against climate change induced impacts
Invasive grass species as potential fire hazard	Shade trees and agro-forestry integrated approach with improved fallow and afforestation	Reduced risk of bush fire during prolonged dry seasons
Low income	Improve livelihood opportunities by Introduction of tree species for NTFP (Galip nut, fruit, honey)	Increased income and higher resilience against climate change induced impacts
Predominate kunai grass and piper potentially suppressing re-growth of native tree species	Afforestation integrated in agro-forestry interventions	Forest re-growth and improved watershed, ecosystem service sand micro-climatic conditions, Options for NTFP

Tab. 3: Problems identified during the survey and possible measures and outcomes

Suggested Activities for integrated micro-watershed management:

- Gravity water supply to selected households
- Biosandfilter
- Soil water conservation measures
- Agro-forestry
- Drip irrigation and proper irrigation scheduling
- Proper lining of distribution channels or usage of poly pipes to avoid seepage losses
- Installation of ram pumps to convey water from streams located in small valleys
- High tanks
- Re-use of nutrient rich water from fish ponds for irrigation
- Treatment of fish pond water discharge to avoid contamination of downstream water stream

Traditional terracing technique ('kekai')

This traditional technique as shown in figure17 is practiced in Gilang village, Selepet LLG, Kambwum district. Communities adapted their cropping technique to the steep slopes and obvious high water run-off rates which potentially lead to soil erosion by using a traditional terracing technique ('kekai'). Barriers along the contour lines are built using a mesh made of branches patched with top soil. This technique reduces water run-off and soil erosion but also retains soil moisture for productive use. Shifting cultivation is practiced whereby plots are left fallow to restore soil fertility.

Fig. 17: Traditionalterracing technique ('kekai')

Traditional terracing technique ('kekai') practiced in Gilang village, Selepet LLG, Kambwum district.

6. Workplan

1. Development of a watershed management plan

<u>The aim of the micro-watershed development plan is to:</u>

- restore/protect the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water in a holistic and sustainable manner
- initiate demand driven and need based watershed planning with active participation of community members
- preventing soil run-off and regenerating of natural vegetation with low cost technological solution complemented by indigenous knowledge
- enable multi-cropping and the introducing diverse agro-based activities, which help to provide sustainable livelihoods to the people residing in the project area
- Create awareness among community members for the management of the natural resources base in a watershed context and holistic way

2. Participatory planning of water supply and design of the system (gravity system and ram pump)
3. Install improved water supply system
4. Introduce biosandfilter
5. Establishment of 2 hedge row demonstration
6. Establishment of a traditional terracing technique ('kekai') demonstration
7. Establishment of 2 improved fallow demonstrations
8. Introduction of tree species for NTFP and for improved fallow
9. Afforastation of kunai grass areas in the lower parts of the watershed
10. Establishment of a tree nursery and conduct training

11. Establishment of nutrient rich fish pond irrigation trials plots
12. Development of by-laws for water source protection and non-burning policy
13. Identify potential sites for improved seed and plant store system

6.1. List of Materials

Type of Material	Size/length	Number of Items	Unit costs	Total costs
Tank	Will be determined after completion of participatory decision-making process for the community water supply system			
Tank				
Poly pipe Ø ?				
Poly pipe Ø ?				
Fittings				
Tap stands				
Material for concrete slab				
Ram Pump + Material and fittings				
Inlet reservoir for ram pump (small tank or concrete reservoir)				
Material for irrigation				
Material for hedge row/kekai demo				
Material for improved fallow demo				
Material for biosandfilter				