UNIVERSITY OF NATURAL RESSOURCES AND LIFE SCIENCES, BOKU, VIENNA

# Technical report on the watershed assessment for the EUCCR-PNG project

Assessment report on the selection process of a pilot site 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

An important activity in Result 3 of the EU funded project "Strengthening food production capacity and the resilience to drought of vulnerable communities" is the participatory establishment of a micro-watershed management model in one of the target sites that would assist 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.

The main objectives of the watershed assessment are

- 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.
- To develop criteria for selecting one pilot site for establishment of a micro-watersheds
- To take lead in reconnaissance surveys of up to three potential sites for selection of the final pilot site
- Review existing approaches, procedures, manuals, guidelines and Standard Operating Procedures that exist on watershed management including but not limited to agro-forestry approaches, check dams, infiltration and dew ponds interventions, contour bunds, terracing, suitable water harvesting (surface and underground) and recycling and usage etc.

Specific consideration for this pilot site selection process:

- Provide comments on the observed watershed environments
- Provide technical advice relevant to the different water harvesting and usages observed
- A summary with suggested improvements for the community management of water sources would be valuable for feedback to the visited sites
- Are there specific aspects at each visited site worth contributing resources into establishing minor water-use systems? E.g. Bio-sand filter is relevant to most areas.

## 2. Principles of Community Watershed Management

Watershed Management (WM) is an integrated approach to the management of natural resources that aims to secure the living conditions of local communities in a sustainable manner (GTZ, citied in Förch and Schütt 2004).

The various parts of the watershed are physically and operationally linked i.e. the various resources are linked not only spatially but also functionally, and the potential benefit from integrated use can be large.

WATER: Water quality, quantity and regime are influenced by watershed conditions. Manipulating different watershed characteristics influence the quality, quantity and regime which are vital for i) human and animal consumption, ii) irrigation, iii) industry, iv) power generation, v) recreation, vi) transportation. Rivers, streams and lakes are the "lifeblood" of our environment. When waterways are healthy, we know the environment can support a diversity of plant and animal species. Adequate water supply and the biological diversity that the watersheds' waters support is the key to socially healthy and ecologically balanced futures. The quality and quantity of water in streams, and the condition of the stream channel and stream bed are generally characterized by the influence of

natural conditions such as the underlying geology, topography, and soils, and the adjacent vegetation, combined with the long history of human influence – with the initial forest clearing, agricultural use, construction of mills, dams and ponds, road and building construction, and modern development, conservation and restoration. The physical characteristics of the stream channel, the quality of the water (both chemical, biological and physical), and the quantity of water during periods of average flow, draught and flooding are all influenced by the interaction of these natural and cultural forces.

**Watershed management**

- Can be referred to as the planned use of drainage basin in accordance with predetermined objectives. It includes the analysis, protection, development, operation or maintenance of the **land**, **vegetation** and **water resources** of the drainage basin to **benefit its residents**. It is a process of formulating and implementing a course of action to protect and restore a watershed through integrated and holistic (system wise) effort
- Watershed management involves management of land surface so as to conserve and utilize the water that falls on the watershed, and to conserve the soil and vegetation for immediate and long term benefits to the farmer, his community and society.
- It implies the careful use of all resources i.e. soil, vegetation and water of the watershed to achieve maximum production with minimum hazard to the natural resources (soil, water and vegetation) and for the well being of people

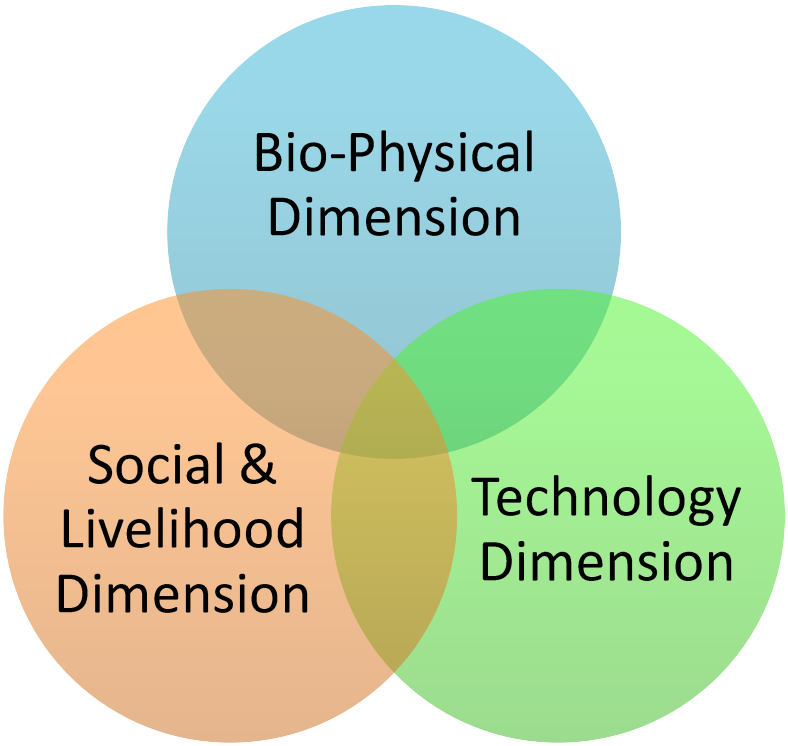


Fig. 1: Dimensions of Watershed Management

The tasks of watershed management includes the treatment of the land (soil, water and vegetation) by using most suitable biological and engineering measures in such a manner that the management work must be economically and socially accepted. Proper management of watershed has a lot to do

with the quality and quantity of runoff from watershed, ground water supply, flood effects and other hydrologic factors

Watershed management means putting in place systems that ensure land resources are preserved, conserved and exploited sustainably now and for future generations. The watershed management approach integrates various aspects of forestry, agriculture, hydrology, ecology, soils, physical climatology and other sciences. But it is more than natural science methods and tools. Rather, watershed management is a continuous and **participatory process** that involves people and aims to improve their livelihoods. A watershed approach can be a coordinating framework for management that attempts to focus public and private, community and individual efforts toward addressing high priority land and water-related issues within the hydrologically-defined geographic area.

Watershed management is simultaneously a technical and social undertaking. From a technical perspective, it involves reducing soil erosion, promoting vegetative cover, and harnessing rainwater resources. From a socioeconomic perspective, it involves coordinating the actions of numerous land users in a watershed who may have multiple, conflicting objectives. Local people need to be involved in decision-making so that they can use their land, animals and other natural resources in a productive way without causing harm to water and soil resources in the upland watershed...or downstream.

The intention is to ensure that environmental objectives are well integrated with local economic, social and cultural goals. Thus effective watershed management is also considered an appropriate approach for addressing food security and poverty alleviation.

**Objectives of watershed management**

In general watershed management is aimed to improve the standard of living of human being in the watershed by increasing his earning capacity, by supply water for different purposes (irrigation, drinking, hydroelectric power), by increasing the productivity of the land (increasing the fertility of the soil), freedom for fear of floods and drought.

There are various objectives of watershed management, mostly dependent on the watershed condition and people's need, but the following are some of the most common objectives:

- To rehabilitate the watershed through proper land use and protection/conservation measures in order to minimize erosion and simultaneously increase the productivity of the land and the income of the farmers.
- To protect, improve or manage the watershed for the benefit of water resources development (domestic water supply, irrigation, and hydropower)
- To protect and enhance the water resources originating in the watershed,
- To manage the watershed in order to minimize natural disaster such as flood, drought and land slide etc
- To minimize siltation of reservoir/dam
- To develop rural areas in the watershed for the benefit of the people and economies of the region. The objective could also be a combination of the above.
- To improve and increase the production of timbers, ranges and wild life resources and

Note: Different objectives call for different techniques, manpower, inputs and approaches in planning. The monitoring and evaluation criteria will also be different. Therefore, main objectives of watershed management should be clearly identified and defined as early as possible before proceeding to the activities.

**Watershed management must be participatory**

Participatory means involving method where the community is motivated to function and contributes as a group to perform various tasks. The management must involve local farmers and other land users and wide community who depend on the land. The adequacy of planning depends on the human element and not only on physical or technical aspects. Therefore, planning must start from people living on the land. The watersheds communities must involve in all stages of implementation of watershed development activities.

**Should follow multi-disciplinary approach and it is a continuous process**

Watershed management is inter-disciplinary approach. Watershed planning is a coordinated analysis by a team of technicians representing various disciplines like hydrology, geology, engineering, soil science, forestry, agronomy, and economists. Each disciple is inter-related with each other.

Many management agencies and organizations realized that effective resource management is never ending and it involves those affected by decisions. Therefore watersheds are practical for integrating these efforts.

**Watershed management must be gender sensitive:**

Women's are the most affected by environmental hardship; for example, they need to walk long hours to fetch increasingly scarce water, firewood and animal dung in addition to attending livestock, to name a few. Their involvement in watershed development planning, implementation and management is the key to ensure that they equally benefit from the various measures

**Watershed management must be build up on local experience, strength.**

Local knowledge is essential to improve the existing technologies, to adopt new ones and to manage natural measures once they are introduced and established

**Watershed management must be realistic, integrated, productive and manageable.**

It must be realistic based up on local capacity, available resources and of government and partner support. Integrated conservation and development base is the guiding principles of watershed management.

The watershed activities must be tangible and quick benefits the households. The measures must accommodate both production and conservation. Management is not only for the sake of conservation it must include both conservation and production.

**Watershed management must be flexible at different level**

Flexibility is needed during the selection of community based, their size (slightly smaller or flexibility or higher than the ranges indicated), and clustering and during the steps of the producer. Flexibility is also essential when considering the choice and design of measures within agreed criteria of quality and integration

**Watershed management must be cost-sharing and empowerment/ownership building**

Cost-sharing by stakeholders contributes to the sustainability of the projects for establishing the responsibility of various stakeholders in the management of the resource. Various forms of local contributes are possible upon social networks and groups formation mechanisms.

**Watershed management must be complementary to food security and rural development** mainstream (like HIV, health, education and others)

Watershed deployment planning should incorporate additional elements related to basic services and social infrastructure.

**Components of Watershed Management**

Major components of Watershed Management needing the special attention of watershed managers are (see animation):

- Management of water resources (e.g., rainwater harvesting);

- Management of soil resources (soil conservation);
- Management of human resources (qualification of resource managers and users, etc.) (Förch and Schütt 2004 b).
- Land management (land use planning, for example);
- Pasture management (area closure, for example);
- Crop yield management (e.g., storage management, marketing);
- Livestock management (e.g., marketing, dairy production);
- Rural energy management (e.g., decentralised use of renewable energy resources);
- Vegetation/biomass management (reforestation, agro forestry, etc.);
- Farm and off-farm activities adding value (e.g., creation of infrastructure) (Förch and Schütt 2004 b).

## 3. Summary of the Assessment and Preliminary Recommendations

### *Rigo Coastal Villages (2 project sites) Gamoga and Makerupu*

**Gamoga village** is in a hillside location less than five kilometers from the coastline.

The main water source of the village is a long term stable spring water source in which a very basic double drum lining had been placed (about 2 m depth). This spring is located on a lightly forested hillside, with gardens surrounding the base of the hills.

The spring is frequently used by women from households downhill in the close surrounding valley. An alternative spring water source is available to households uphill of this spring. The spring takes overnight to fully refill after being used the previous day. The spring is used for multiple purposes for laundry or dish washing or drinking water usage.

According to some villagers, landowners located upstream of the spring impact the quality of the source, which would require a community intervention to solve this issue.

An alternative source of spring water had been accessed in the 1980's under a DAL cattle project, which included a small damn and a small bore waterhole pumping station for supplying water to several village taps shared by village households.

The use of this water source has been discontinued for about three decades after road developments damaged the piping and the pump station was removed, while the damn refilled with sediments.

There are three other streams on opposing sides of the valley area. One hillside stream passes through food garden areas and is not used for household purposes. Another water stream passes through the opposite end of the valley and has a separate source at a second ground water well (not visited). This garden creek is also used for household purposes. The third stream in this valley area is mostly wet weather drainage.

A **community focus group discussion** was held and the main issues of discussion were captured by project coordinator Dr. Michael Dom and are quoted as follows:

> *"Some notable issues were: The water dam and pump station was disused after road works destroyed the piping but there was little effort to reinstall the system since it was dependent on a discontinued DAL cattle project. There is currently more intensive land development within the area, and although the communities have suggested that a water tank be placed on a higher hilltop to pump water for storage, there is as yet no determined plan to develop this household water source. In addition, there avenues for discussing cautionary road development have not yet been explored.*
>
> *The old spring water drum well remains unprotected. There are no standing by-laws on the use of this water resource. However, women who are the main users have some communal agreements on shared use. The use of this drum well nevertheless remains a contentious issue during dry periods when other water sources are less reliable.*
>
> *It was estimated that up to 400 head in about 60 households access the old ground water source. Daily usage was estimated at three or four daily trips, collecting four or five 15 L plastic bottles for household use.*
>
> *Women commented that when under intensive use during dry seasons the spring may take all day to refill. Also the water level tends to be much lower than 50 cm during drought, possibly allowing contamination of the harvested water. No crop irrigation use is made of this water source but some water is used for livestock, particularly pigs and less for village chickens.*
>
> *It was noted that land owner groups for both ground water well sources were present at the meeting as was a village magistrate. There was a generally good conversation between the participating members which demonstrated good understanding of water use and access issues.*
>
> *No major commitment to watershed use was indicated to the community. However, the point was stressed that community agreement on water usage and the establishment of by-laws to protect the natural water sources was needed.*
>
> *We suggested that one way in which further advice on the use of the spring water source may be provided through the project was to conduct pumping tests to explore the catchment volume output annually and seasonally.*
>
> *While men are the major resource owner group, and concerned mostly with the physical development of water systems, women are the major user group and have a good understanding of the need to properly organize user rights and protection measures.*
>
> *One concern the women raised was the placement of pit latrines along the waterways. Another general concern was housing development and food gardens along the hillside on which the old ground well is situated.*
>
> *Notably the selected crop bulking field site at Gamoga village is situated some distance away from the water sources and may provide a reason for demonstrating simple water piping/harvesting and irrigation technology."*

## Conclusions and Recommendations:

1. Proper lining of the spring with concrete well lining, proper spring protection measures and use of geo-fabrics as filter and separation material and separation gravel. This will significantly improve the water quality and reduce the risk of water pollution.
2. Conduct pumping tests to explore the catchment volume output annually and seasonally
3. Input on proper watershed and water resource management (multiple use). This mainly serves the protection of the spring against point source contamination by settlers located upstream and in the catchment area of the spring.
4. Biosandfilter

**Makerupu village** was visited mainly to observe the village wells to identify possible options improvement of the existing well construction. The water from the wells is the only water source utilized by the surrounding community along the Rigo coastline. The well lining is only made of bent corrugated iron sheets and the well is not protected which can easily lead to contamination of the water through open defecation of free roaming livestock. The fine texture of the soil (sandy loam) only provides a minimal barrier and filter function, thus the well water shows a high level of turbidity due to dissolved fine textured soil.

## Conclusions and Recommendations:

1. Proper concrete well lining and use of geo-fabrics as filter and separation material and separation gravel to minimize the impact of intrusion of fine sediments contaminating the well water. This will not only minimize the turbidity of the well water and significantly improve the water quality but also reduce the risk of water pollution by soil adsorbed and absorbed contaminants intruding the well unfiltered.
2. Protect the well from air borne debris and flood water run-off.
3. Establish a fenced area around the well for well protection. This will minimize the impact of contamination of well water through open defecation of free roaming animals and also protect the well from damages from debris during flooding events.
4. Biosandfilter

Include image of concrete well lining from Derin

## *Kome LLG Menyamya District (four project sites)*

**Taita village (Group 1) Kotai speaking area**

The community is located at a hillside with a high variation in slope angle and aspect. The main vegetation cover is bare grassland, shrubs and some trees, which don't form a closed forest cover. The main agricultural activity of the community members are coffee farming and fish farming. This community has an extensive fish pond systems (tilapia and carp) relying on two of three spring water sources located higher up the mountain side. According to the community the springs are perennial and provide a consistent domestic water supply and water for the fish ponds. Minor crop irrigation activities are done during dry seasons in nearby food gardens along the slopes of the fish pond area. The water from the springs is conveyed through an open channel system, bamboo and poly piping systems supplying fresh water to the fish ponds and homesteads. During regular years no irrigation is performed; however during prolong dry seasons water from the springs is also used for crop production.

During a village mapping exercise it became obvious that downstream effects of the extensive fish farming activity is a big issues for downstream users. Even more so as fish farming is a major activity in the whole valley. Thus two major activities can be envisaged and combined. These include water usage for improving production efficiency of fish ponds, recycling nutrients of fish pond effluents through a water treatment (soil filter) and trialing small-scale irrigation with nutrient rich pond-water. The treated fish pond water can be released promptly to downstream waterways. In the adjacent communities the use of bio-sand filter can be promoted for providing cleaned potable water for communities downstream. Quantitative measurements of the utilized spring and the catchment can be done to assess the quantity of the available water for multiple uses in the watershed. To minimize the usage of fresh water from the springs for fish ponds, water harvesting systems integrated in the landscape (retention ponds) can be envisaged as an option. Integration of agro forestry systems and soil water protection measures have the potential to minimize water losses through evapotranspiration during drought and eventually increase the water volume stored in the soil available for productive use.

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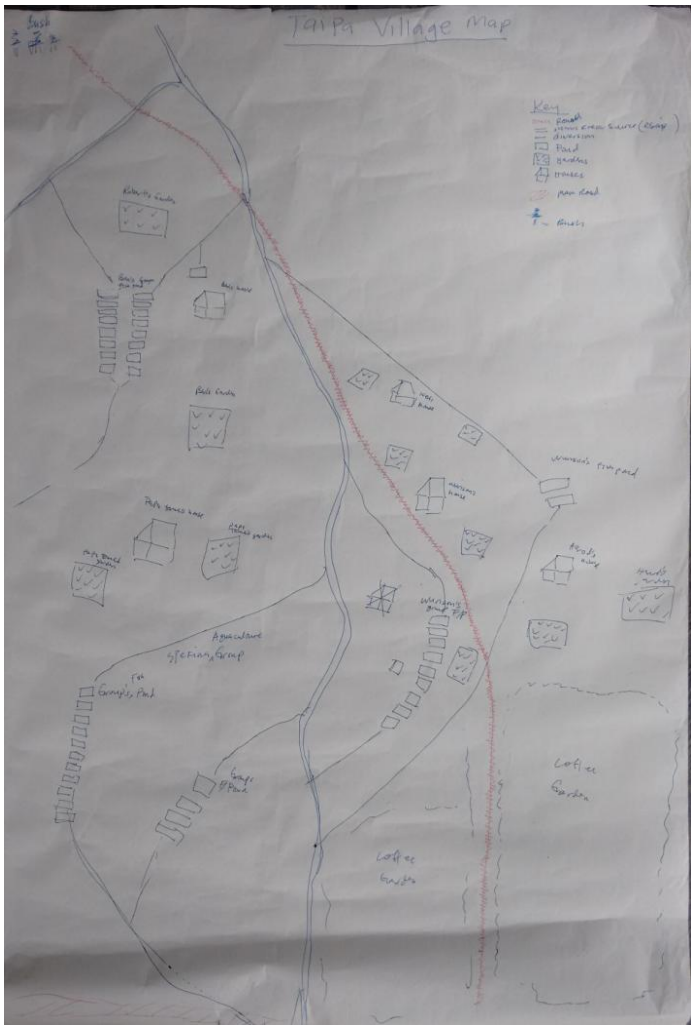


**Nambawan Bridge (Group 2)**

This community is a settler group from the Menya speaking tribes who have settled on land belonging to Kotai speaking tribes (see Nambawan Bridge (Group 3)). These settlers were apparently refugees from a tribal conflict that happened at least a generation ago. According to one senior community member the drainage channels to access this water was probably made some time after WWII, and hence a tribal agreement may have been made with village chiefs of Nambawan Bridge (Group 3).

A transect walk was conducted and discussions were captured by project coordinator Dr. Michael Dom and are quoted as follows:

> "*This community has dug a systematic network of small water drains for supplying fish ponds (tilapia and carp) integrated within, standing coffee crop and food gardens, and into household areas. The main water source however is situated higher up the mountain on land belonging to the landowner, Russ. According to one senior community member the drainage channels to access this water was probably made some time after WWII, and hence a tribal agreement may have been made with Russ et al. Water for household use is still accessed from Pei Creek, which runs out of the same mountain spring source."*

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The community has also dug some open channels to divert water to their food gardens to practice flood irrigation during dry seasons as shown in picture xxx. The morphological set-up of this area is very similar to the one described for Taita village (Group 1). Main source of income is coffee and fish farming. Similar to xxx the extensive fish farming activity is a big issue for downstream users. Even more so, as fish farming is a major activity in the whole valley and poses a threat to the water quality of the main river draining the valley. Thus two major activities can be envisaged and combined. These include water usage for improving production efficiency of fish ponds, recycling nutrients of fish pond effluents through a water treatment (soil filter) and improving existing small-scale irrigation with nutrient rich pond-water. The treated fish pond water can be released promptly to downstream waterways. In the adjacent communities the use of bio-sand filter can be promoted for providing cleaned potable water for communities downstream. A couple of dead trees located downstream of the large area occupied by fish ponds can be an indicator for underground water seepage and waterlogging, which might pose a threat to the coffee gardens in den low lying areas. This however is not related to the main objective of the project and therefore not a main issue that needs further investigation by the project team. Food security due to impact of El Nino events doesn't seem to be

an issue in this community, since fish is there number one fall back option during times of drought. Secondly the utilized water source is very reliable and will not dry out during El Nino events. The fish pond system also provides a rather big reservoir of water for which can cater for water needs (food production) during very dry seasons.

**Nambawan Bridge (Group 3)**

This Kotai speaking community is the local landowner tribe.

A transect walk revealed that the ground water well, Hiwali spring, was situated further inland and uphill. The area is mainly covered by bare grassland with some planted trees along ridges where houses are built. Crop cultivation is mainly practiced along steeper slopes.

A lively discussion took place during the transect walk and close to Hiwali spring. The discussions were captured by project coordinator Dr. Michael Dom and are quoted as follows:

> *"Hiwali water well is sourced directly from the wild undergrowth using bamboo pipes, with a small pond area which allows space for water collection and use. The run-off flows down stream and is used by all other households for laundry or bathing water. Run-off from the water pool area is also channeled into the systematic fish ponds dug throughout the lower valley and maintained by at least four separate family members. Some water is drained into coffee gardens from the fish pond system. There is also a rough bamboo pipe construction used by one family member (Nelson Abel) to provide water to fish ponds across from the coffee garden area. There was little expression of the need for irrigation of crops, even from a mother of the family (Rosalyn Abel). It was emphasized by a leading community member (Manase Simon) that they had a wish to develop the ground water source into a bore water supply and pipe the water across one valley to a hillside above the village where they wanted a Southern Cross tank to be placed to supply water to the entire community. This desire had purportedly been expressed to several donor project agencies viz WHO and PNGDF among other vague references.*
>
> *In reference to the fish pond activity the Action Coordinator had stressed to the Russ and the community that Hiwali water source was fragile and the outflow should be measured before any other extensive digging or drilling development is made which could potentially damage the water source permanently."*

During the discussion it became obvious that there exists an urgent need for community meeting with the leaders of Nambawan Bridge (Group 2) community. This mainly includes an agreement of the use of Pei Creek and a mountain spring, which is located on land belonging to Nambawan Bridge (Group 3) community. Due to the location, this community however can't access the water an also expressed their wish to convey the water closer to their homesteads and food gardens. This is however by no means a trivial technical undertaking and beyond the financial capacity of the project. Due to the fact that there seems to be a dispute about the utilization and access to the water sources, it doesn't seem to be advisable to work with the Nambawan Bridge (Group 2 and 3) communities.

**Vaiye village (Group 4), Menya speaking area**

This community is situated on a steep sided and densely forested mountain side. There is major coffee production with a large number of fish ponds throughout the slopes and valleys. The mountainside is well watered by three permanent water sources, two of which reportedly may dry up at 2-3 year intervals, most likely associated with lower seasonal rainfall. One central spring-water source 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.

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

A lively discussion took place during a community discussion and the transect walk. The discussions were captured by project coordinator Dr. Michael Dom and are quoted as follows:

> *"Ziga spring-water was considered by PNG Waterboard for providing a supply to valley communities, Concordia Lutheran Mission and as far as Kome LLG station. The community was agreeable and had requested that the piping, tank and other materials should be supplied for them to collectively install the catchment system. Further advice may be forthcoming on this prospective development.*
>
> *Mr. Martin has established by-laws which protect the surrounding bush land, food garden areas, fish pond areas, drainage systems and water piping systems. His knowledge of environmental management was learned from government officers during his father's generation probably in the 1960-70's.*
>
> *Mr. Solomon has expressed that the area has been overhunted by the younger generation, probably in reference to the increased need for fish pond farming, prominently involving his own sons, and village chicken farming which he also champions.*
>
> *Ziga spring-water source opens close to the side of the main road. This road is well used by coffee producers and buyers although it is poorly maintained.*
>
> *Some ponds in swampy areas tend to dry out during the dry season and drought if there is no permanent water stream.*
>
> *There is a majority of youth involvement in the water source management. A recent event hosted by the Concordia Lutheran Mission Station has currently placed a large bore pipe (~300 m) which still supplies water to lower communities. However, as this is likely to be removed the community is now wishing to source one for their own purposes.*
>
> *Although there is less need of irrigation in the higher slopes there was recognition of the need for irrigation in food gardens of communities on the lower slopes, which are mainly kunai grass areas."*

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 Ziga creek to the fishponds and the food gardens. During the transect walk a number of silted up nonfunctional channels were identified. Those channels conveyed water to various parts of the cultivated land. The reason for the discontinued use of the channels could not be determined. Mainly the channels which supply water to the fish ponds however are functional and in use. This is however a clear indication

that irrigation was practiced, which provides a good scope for watershed management 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.

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.

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 Ziga stream. 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. Additionally water harvesting through the introduction of water retention ponds can be considered. Quantitative measurements of the utilized spring and the catchment can be done to assess the quantity of the available water for multiple uses in the watershed. To minimize the usage of fresh water from the springs for fish ponds, water harvesting systems integrated in the landscape (retention ponds) can be envisaged as an option. Integration of agro forestry systems and soil water protection measures have the potential to minimize water losses through evapotranspiration during drought and eventually increase the water volume stored in the soil available for productive use.

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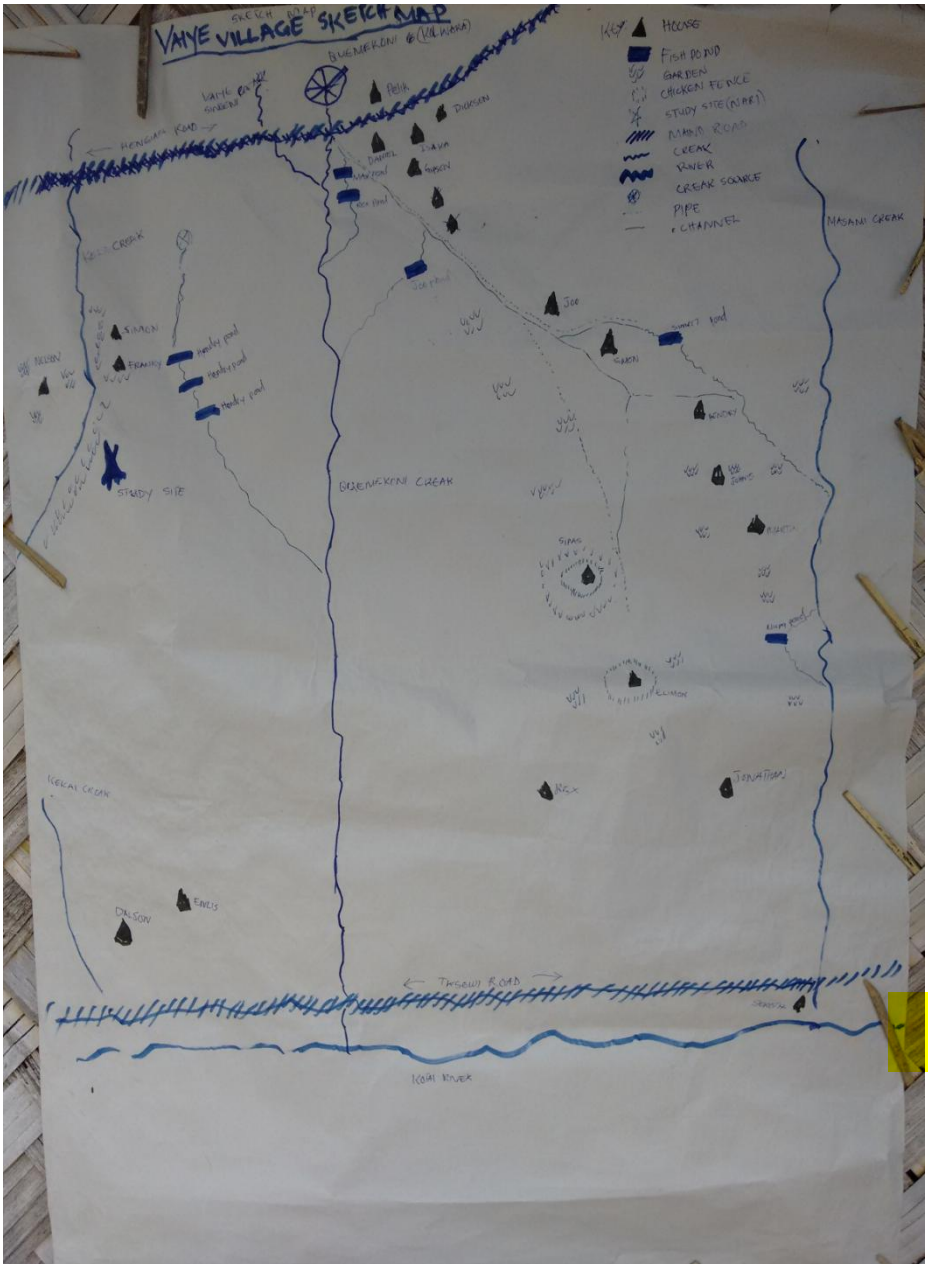
VAIYE VILLAGE SKETCH MAP
KEY
HOUSE
FISH POND
GARDEN
CHICKEN FENCE
STUDY SITE (NAME)
MAIN ROAD
CREEK
RIVER
CREEK SOURCE
PIPE
CHANNEL
MASANI CREEK
STUDY SITE
BUENEKONI CREEK
TWISEWI ROAD
KOIAI RIVER

## Conclusions and Recommendations:

All 4 sites located in Menyama district are suitable as pilot sites, however due to potential tensions arising between the two communities group 2 and 3 at Nambawan Bridge, due to the ownership of the main water source, it is not recommendable to select one of the two sites as the main project site for watershed development.

Due to the conducive environment for watershed management and the pro-active community engagement during the assessment at **Taita village** (Group 1) and **Vaiye village** (Group 4), I would recommend these two communities for further in-depth survey, which will lead to the final selection of the pilot watershed and the development of the watershed management plan.

Suggested Activities for integrated micro-watershed management:

- Water capture and harvesting (irrigation and domestic use)
- Retention ponds (storage and soil water recharge)
- 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

## *Selepet LLG Kabwum District (three project sites)*

The village communities that were selected for the watershed assessment are Wap and Konimdo in the dry lowlands (Komba Zone 1) and Gilang village in the wet highlands behind Kabwum Station (Selepet Zone 2). The selected communities are situated in very different micro-climatic environments. This relates to availability of water for domestic and productive use and the natural vegetation cover, which also affects the micro-climatic conditions and cultivation practices.

**Site 1 Gilang village area**:

This community is located in the wet highland areas, which is covered by forest and characterized by high and regular rainfall. The topography of this mountain side environment is favorable for the micro-climatic conditions. The mountain ridge acts as a barrier for moist air drifting from the sea further inland. The moist and humid air cools down and forms cloud formations that release the moisture content as rainfall in proximity of the highland area. Whereas the dry lowland areas receive significantly less rainfall and are affected by high evaporation rates due to prolonged sunshine hours and less cloud cover.

Communities adapted their cropping technique to the steep slopes and obvious high run-off rates which potentially leads 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.

There are no apparent problems with food security due to prolonged dry seasons. Therefore this side is not suitable as a pilot study side for micro-watershed interventions.

**Site 2 Konimdo village area:**

As mentioned, this community is located in the dry lowland areas of the valley. The area receives significantly less rainfall compared to the mountain area, which impacts the local natural vegetation. Forest cover is not as dense and alternates with shrubby patches. There are several small mountain streams that drain the steep ridges into the valley and provide household water. Irrigation is not being practiced. Water sources are used for fish ponds and convenient locations for washing coffee, which is a major cash crop across the entire area of Zone 2. By visual observation of the flow rate of the stream it is however very unlikely that the quantity of the water can be used to cater for the crop water requirements of the cultivated crops during prolonged dry seasons. Due to the soil conditions, which can be described as sandy loam with very low organic matter content, the water holding capacity seems to be very low. The combination of the soil condition and the limited availability of water limit the option to introduce irrigation technologies to improve food security during drought.

Therefore viable options for this area are introduction of agro forestry, incremental increase of soil organic matter content and measures to increase soil moisture content and reduce evaporation losses. The introduction of water retentions ponds might also be considered, however due to the soil texture lining of the ponds with plastic sheets has to be considered to reduce seepage losses.

Much of the arable land is zoned into regularly farmed and fallowed land use. Cultivation of crop lands may last up to two years, while fallow may last for up to five years.

A lively discussion took place during the village mapping exercise and the transect walk. The discussions were captured by project coordinator Dr. Michael Dom and are quoted as follows:

> *"Women in the meeting group recognized that water becomes contaminated. The bio-sand filter was expressed as being relevant for purifying drinking and cooking water.*
>
> *Mulching and green manure, the use of fallow crops and hedge rows or tree boundaries were discussed as being relevant techniques for soil moisture conservation.*
>
> *Crop improvement was a noted requirement for increasing yields of staple crops – it is uncertain if these are in decline and for what reason harvest may lower than expected.*
>
> *Processing and post-harvest practices were found to be agreeable for women's technology and potentially for producing pig and poultry feed.*
>
> *A field visit was conducted to four identified food garden areas belonging to Mr. Matthew Gulo of Konimdo village. His 2015 food crops had been totally destroyed during the last drought event and he had had to move his seed crop into the forested mountains higher up the valley for protection from the dry and hot weather. Matthew had also prepared food gardens parallel to his 2015 damaged garden area for 2016 and 2017 respectively. All three plots are to be put into cultivation consecutively over 2019, 2021 and 2023 respectively. NOTE: This crop land provides a convenient area for observing and demonstrating fallow land management and trialing of improved crops.*
>
> *Observations were that the water retention was influenced by availability of organic material from fallow growth. However, in areas where there was burning of the undergrowth much of this organic matter was destroyed leading to some clearly poorer soil structure."*

**Site 3 Wap village area:**

The discussions and observation during the transect walk were captured by project coordinator Dr. Michael Dom and are quoted as follows:

> *"Two large standing pools were observed at the bottom of a dominating limestone cliff formation (Niom mountain). One of these is permanent throughout the year. Both have been seeded with tilapia and carp.*
>
> *The entire area is under the canopy of coffee and coffee shade trees. At least two major ground water holes were observed, serving two sections of the large village group, while the central Wap village has mountain water sources, formerly piped and tapped by ADRA – currently requiring some pipe maintenance.*
>
> *There was observable use of a community coffee pulping machine near one water source.*
>
> *There is some recognition of the need to take care of the water sources however this does not appear to be very strongly emphasized or regulated by the local village authorities or villagers.*
>
> *The major observable problem was that the soil was a thin layer over very broken limestone rock area. The soil temperatures were reported to rise very quickly and kill off some tuberizing crops and bananas. In some areas where deep soils had been gathered there was visibly better nutrient quality, from observed growth."*

## Conclusion and Recommendation:

There are no apparent problems with food security due to prolonged dry seasons at Gilang village. Therefore this side is not suitable as a pilot study side for micro-watershed interventions.

Due to limited accessibility (sites are mainly accessibly by airplane) and lack of a proper water source which provides sufficient water for domestic and agricultural use and the described soil conditions, the Konimdo is not recommended as potential pilot site. The development of water sources, which might potentially cater for all water use scenarios, would be beyond the capacity of the project.

Main focus of Wap community seems to be on coffee. Water supply had be installed by ADRA, which is out of operation due to lack of maintenance. It is questionable whether food security is a problem during El Nino events. Rehabilitation of broken water supply systems is certainly not within the scope of the project and is not recommended.

However some activities are recommended which will certainly improve the communities' resilience to climate change induced impacts.

- Bio-sand filter for purifying drinking water
- Plastic sheet lined water retention ponds placed across the area at suitable locations with proper run-off areas attached for water harvesting
- Mulching and green manure, the use of fallow crops and hedge rows or tree boundaries for soil moisture conservation.
- Crop improvement was a noted requirement for increasing yields of staple crops
- Processing and post-harvest practices

## 4. Overall Conclusion and Recommendation

Due to the conducive environment for watershed management and the pro-active community engagement during the assessment at **Taita village** (group 1) and **Vaiye village** (Group 4) in Menyamya district, I recommend these two communities for further in-depth survey, which will lead to the final selection of the pilot watershed. It is planned that a BOKU Master student jointly with a selected NARI researcher will conduct a survey to delineate the two selected watersheds. This research activity will contribute to the participatory establishment of a micro-watershed management model in one of the target sites that assists in enhancing water capture and storage capacities and soil water conservation of the target communities to augment and manage agricultural and domestic water supply and use during dry periods following the MUS (Multiple Use System) approach. After the final selection of the pilot site a combination of development of a micro-watershed model using participatory and learning centered methods for scenario development and the assessment of total economic value (TEV) of the multiple ecosystem services of the preserved water catchment can be done.

**Main objective of the work is the delineation of two micro-watersheds:**

- 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, water use scenarios and land use practices
- Recording of rainfall
- Identify community fallback options during times of drought (water and food)
- Assessment of bio-diversity and ecosystem services
- Protection of functioning ecosystems and enhancement of ecosystem services through watershed management model
- Micro-watershed management model and scenario development (technological, bio-physical and social & livelihood dimension)
- Participatory and learning centred methods for development.