Proof of concept for 3R and the watershed approach for coastal communities

As a means of climate change adaptation in the Philippines

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As a means of climate change adaptation in the Philippines

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Introduction

This report develops for proof of concept the 3R (Retention, Recharge and Reuse of water resources) in climate change adaptation strategies in coastal communities in the Philippines. It evaluates existing 3R interventions and watershed approaches around Coron and researches the potential inclusion of 3R measures in fundraising strategies for 3R and watershed protection and management strategies in climate change adaptation for coastal and island communities in the Philippines.

Climate change heavily impacts coastal and island communities, exposing them to typhoons, storm surges and wave actions as well as heavy monsoon rains. Additionally, these areas also suffer from climate change induced slow onset events such as increased temperature and changes in precipitation patterns, combined with human induced pressures on water resource availability and quality. 3R interventions potentially provide the most sustainable solution in climate change adaptation in coastal and island communities.

The proof of concept consists of three parts:

- The first part evaluates the potential of 3R measures in a watershed or catchment approach in Tara, Buenavista and Malawig (Coron). The approach focusses on interventions as means to address the encountered climate induced problems of the people. This evaluation shows that the interventions provided the three communities with **sustainable dry season freshwater access, which was previously not the case.**
- The second part looks at the opportunities based on risk evaluations and climate assessments of the Guiuan, Surigao and Bantayan Island Group: Bantayan, Madridejos, Santa Fe coastal communities**. The evaluation enforces the applicability of 3R methods as a water resources strategy**. The watershed approach however needs to be brought to another level since some of the islands have no surface water flow. The advice is to consider subsurface water movement as equally important. These subsurface water flows can be augmented using 3R techniques.
- The third part looks at 3R and watershed methods compared to other possible options. Here **the 3R method comes out strongly as a no regret option with positive impact on the long-term water sustainability**.
- The fourth part places 3R interventions in the context of the SDGs and the SFDRR, showing that **the interventions contribute to the desired global outputs**

1. 3R measures addressing climate induced problems of coastal communities

1.1 3R measures at watershed level, what is the concept?

3R stands for retention, recharge and reuse, comprising methods and techniques which positively approach water resources management. To positively approach water resources means that the interventions sustainably increase water availability rather than assuming water resources are finite. The methods and techniques aim to capture water when it is available to store it or reuse it when needed. As outlined in the water harvesting guidelines (2013: 6)[1]:

This approach focuses on water buffering in order to better manage natural recharge, and to extend the chain of water use. When water is abundant, a large portion is commonly lost: unused: through floods, surface runoff and evaporation. Through buffering techniques this unused water can be retained. Four main categories, or strategies, of buffering can be distinguished:
(a) Groundwater recharge and storage.
(b) Soil moisture conservation in the root zone.
(c) Closed tank storage.
(d) Open surface water storage.
In general, the buffering capacity increases as one moves from small to large storage, and from surface to soil or groundwater storage. Often different types of storage complement each other in water buffering at landscape and basin level. Reuse focusses on keeping water in the system, for instance the use of household wastewater for small scale gardening. The figures below show examples from all over the world.

Figure 1 from left to right: Road water harvesting cistern Yemen, rooftop water harvesting Uganda, live check dam Indonesia (source: 3R deal book 2019 and by author)

[1] Mekdaschi Studer, R. and Liniger, H. 2013. Water Harvesting: Guidelines to Good Practice. Centre for Development and Environment (CDE), Bern; Rainwater Harvesting Implementation Network (RAIN), Amsterdam; MetaMeta, Wageningen; The International Fund for Agricultural Development (IFAD), Rome.

Figure 3 left, harvesting water from the rocks in dry lands of Kenya, right, simple infiltration pit to reduce flooding and increase recharge Indonesia (Picture by author)

Figure 2 full terracing of the hills harvesting all the rainfall, creating soil moisture and recharging the aquifers in Ethiopia (source 3R deal book 2019)

Watersheds or catchment

3R entails the collection of renewable rainwater sources. Its techniques maximize on the available water to deliver for water use systems at household or farm level to allow individual use. 3R techniques also contribute to watershed or catchment approaches.

Many different definitions of a watershed, catchment or basin exist and often the terms are used interchangeably. Here we use the hydrological definition that a catchment, watershed of basin is a drainage area with one outflow point. For instance, Figure 4 shows the catchment of Magepanda, on the island of Flores in Eastern Indonesia where the main river drains. The black line outlines the upstream drainage areas. Water that falls outside the catchment boundaries will not drain to the sea at the outflow point. That water falls in the catchment does not mean it always drains into the river, a large part will recharge into the ground or evaporate. The catchment outlines the area where surface water would flow.

Catchment approaches are gaining ground since it is becoming more and more apparent that problems with downstream drought or flooding require an approach that looks at upstream land use or water management

3R technologies address upstream and downstream issues. Often this takes the form of upstream water harvesting or recharge at a time when downstream flooding risks occur. The harvested water then can be used later or finds its way to the below stream users at a much slower pace, arriving at a time when they need it. Figure 5 for instance depicts a schematic representation of a catchment whereby at different places different 3R techniques take place.

Figure 4 Magepanda catchment Flores Indonesia.

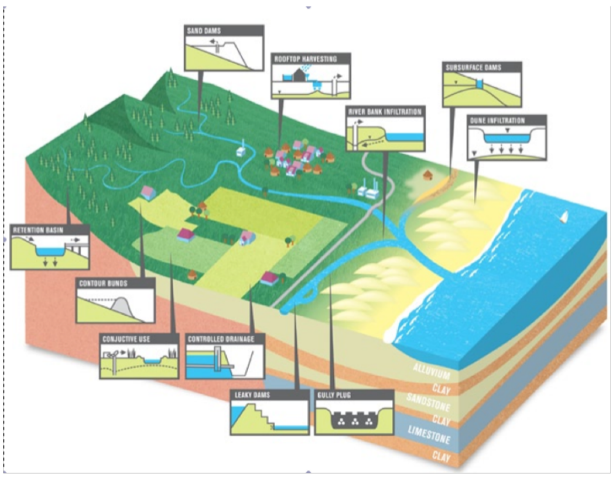

Figure 5 schematic representation of different measures at different places in the catchment

1.2 Climate induced problems of Tara, Buenavista and Malawig negatively impacting the resource base

The climate change adaptation framework (CCAF) for Coron shows a number of climate scenarios that negatively impact the resource base
The general scenarios include:

- Increased temperature;
- Varying quantity and intensity and timing of rainfall patterns;
- Decreased tropical cyclone frequencies and increased tropical cyclone intensities;

Specific Scenarios (to 2050)

- General increased in mean temperature from 26.9˚C to 30.2˚C or an increase of 0.9 ˚C to 2.1 ˚C;
- Warmer days during dry season with temperature expected to rise from 28.1˚C to 30.2 ˚C;
- Decrease in rainfall change of at least -25% or 581.1mm from 781.7 mm (RCP4.5/8.5);
- Drier season from December to May (Drier dry season)
- Erratic rainfall.
- Sea Level Rise Projection (81 years – end 2st century) 0.24 cm yearly increase or 20 cm approximately within the under the worst climate scenario
- Decrease in typhoon frequencies but increased typhoon intensities

These climate scenarios impacted the coastal communities in a number of ways, below three different impacts are described.

The first are **typhoons, storm surges and wave actions as well as heavy monsoon rains** will see an increase in intensity. Particularly in relation to typhoon Haiyan, the coastal lands where severely eroded; springs and ponds silted up (see Figure 7); creeks that where once only a meter deep are now 3 or 4 meter deep (see Figure 6); wells that had been used for years got buried completely by the soils that came down due to the torrential rains. Water sources diminished, got salty or polluted with runoff water and people needed to travel by boat to other locations to get their drinking water. On one of the islands (Gina: 12° 10.517'N 120° 15.328'E) people gave an account that typhoon Haiyan's rains made the soils from the hillside come down, meeting with the sand and gravel from the beach that was pushed up by the sea. It buried the houses but also the only community well on the island (Figure 7). Digging it out was a task in itself, but only to find that with every rainy season it gets silted up again and the water becomes undrinkable.

Figure 6 Gina well, dug out again but runoff water seeps in

Figure 7 Gully in Cabugao, this used to be just half a meter deep and is now up to 4 meters deep

Slow onset events such as sea level rise, increased temperature and changes in precipitation patterns created and continue to create a different set of issues. These include saltwater intrusion into freshwater resources and changing flows of seasonal rivers. The last reduces the recharge of wells due to prolonged dry periods. Communities described climate change as "increasing heat" impacting their resources such as water and agricultural land. In an assessment by Cordaid on the islands in Coron municipality, it was found that people suffered the periodical absence of water, particularly drinking water. Sea level rise also exposes coastal lands to further erosion. Because the majority of the population in these islands lives on or near the beach, the impact cannot be underestimated.

Human induced pressures compounding climate change. Increasing pressure on land and water resources the climate related risks described above. Many of the traditional fishing communities sought additional income in agriculture by planting upland rice, maize and cassava by using the Kaingin system of burning and planting, leaving large stretches of land bare (see Figure 8). In other areas the planting of cashew nut trees has also led to higher runoff off from the land since cashew precludes undergrowth.

Figure 6 Burned forest planted with maize and cassava

While one would definitely want the fishing communities to develop a more diversified pattern of livelihood opportunities, the islands landscape climatic pressures and resource base cannot accommodate crude forms of agriculture that leaves the land susceptible to high runoff as well as depleted by burning. The increase in torrential rains and prolonged dry periods culminate in erosion, high runoff in the wet season and reduced recharge of springs and shallow well aquifers.

Additionally, beekeepers, hunters and livestock keepers burned the tops of the hills regularly. They do so to access bee nests, chase animals or create fresh grass for livestock. This creates large stretches of bare lands that erode with the first rains.

1.3 3R solutions reduce climate change induced pressure on land and water resources in Tara Buenavista Malawig, northern Palawan province

In an area where more than 2,5 cubic meter of rainwater falls on every square meter of land annually it is hard to believe that people suffer water shortage. However, the bulk of this water flows directly to the sea, not getting the time nor the opportunity to be retained or recharged into the ground. In many of the coastal and island communities the recharged fresh groundwater provides the only source of water for domestic use. This water appears in three different forms.

- As springs in the uphill areas
- Downstream around seasonal creeks
- As a freshwater lens that floats on top of the underground salty groundwater

Cordaid, with technical support from RAIN, developed a program on 3R solutions with coastal communities from 2016. With the coastal communities of Tara, Buenavista and Malawig the program and community groups implemented a variety of interventions. These interventions primarily targeted the main concern of the communities, the salinization or desiccation of the water sources: wells and springs dried up during the dry season or got salty and polluted in the wet season. One of the most used techniques intervened in the catchment opportunities for increasing the freshwater resource base. These were called water traps locally, simple permeable cascading check dams that slowed down the flow and recharged the groundwater above stream of water sources such as springs and wells. Slowing down the water allowed it to sink into the underground, creating a water buffer which moved slower towards the spring or well aquifer, or was released after the rainy season by the natural lateral flows of the land.

For instance, one source, a well at Kalmong creek on the island of Tara was often used as a backup for the town proper when other sources stopped to produce. The creek is roughly 450 to 500 meters long and 2 to 3 meters wide at the base, dropping 50 meters in altitude. The stream has water during the rainy season. At the foot of the hill was a well which provided water the whole year but receded considerably in yield during the dry period. It caused concerns that, in light of a growing population and the mentioned climate change the source would dry up at some stage. Trained community members constructed a series of 8 water traps of loose stones (see Figure 9). With a distance of 20 to 30 meter between them. As can be seen in the picture, the water traps reduce the speed of the water and increase the water level in the stream while still allowing it to pass down slowly through the openings between the stones. The water traps thereby reduced the speed of the water runoff and particularly in the dryer months, they force water into the underground where it will take a lot longer for it to travel to the sea. **Community members stated that the level of water in the dry season was now more than sufficient to cater for any of their fresh water uses.**

Figure 7 one of the 'water traps' at Kailong creek, Tara

Similarly, typhoon Haiyan devastated the coastal community of Malawig barangay. People relied on a spring source that tended to dry in the dry season, resulting in them needing to transport water by boat from nearby sitios. Using a combination of approaches, amongst which water retention (water harvesting) in large tanks at public buildings as well as water traps above stream from the spring intake box, the water resources availability in the dry season changed positively.

The water resource from Malawig derived from Mapula creek, a kilometer to the east of the proper. Like the one in Tara, and many more around the coast, this is a seasonal creek, roughly 430 meters long, a small catchment of only 33 hectares with an elevation difference of 255 meters. With the appropriate catchment protection and additional 3R interventions (a series of 5 checkdams) the creek now produces ample water year-round according to the people who use the water source.

Figure 8 Water meters for individual water users

Additional investments from LGU and Cordaid contributed to appropriate water use and the Malawig community moved from level 1 to level 3 water users (see Figure 10). During the evaluation a total of 5 different 3R systems were visited, all of which positively contributed to the water availability in the surrounding communities. Additionally, these measures are so called no regret measures, they do not rely on non-renewable resources, require very little operation and maintenance and only harvest water that would otherwise go to the sea. The main point also is that often these measures contribute to the only water resource available in the area. For remote island communities there are often no viable alternatives besides going to the mainland to collect water.

By working with communities on locally available options, 3R solutions have allowed people to take more control over their own resources and look at water resources in a positive way, as an opportunity to develop local resilience. At first people were apprehensive about the impact of the check dams, but as confidence grew more people started to take an interest and for instance the 3R group from Tara proper started to guide other community groups from surrounding villages in Coron municipality to work on their 3R solutions.

3R initiatives were made part of the BWSA (Barangay Water and Sanitation Association) in both villages. Cordaid developed the capacity of these associations, working on their legitimization and operation and maintenance as well as developing a system of cost recovery to ensure funds are available for any repairs in the water distribution system. Currently the groups are in the process of registration as a basis of assisting them to become counterparts of community and local government programs

There are now 107 households in Tara proper using level 2 water system and 104 households in Malawig who have their own household water connection. The 3R interventions shielded the water resources from the potential negative impact of climate change. In Malawig the water contributes to a few hectares of farmland that receive irrigation.

Other 3R solutions included the construction of roof water harvesting tanks at institutions. This technology is well known all over the world and needs no further elaborations. It works that is evident from the evaluation, the main issues to be tackled remain community buy in for (at least) operation and maintenance. The team also piloted terracing and bush lines in agricultural land and anti-burning measures as well as flooding control. These measures combine a number of positive impacts to reduce climate change pressures. Notably the reduction of runoff, preventing erosion and reducing the impact of increased precipitation. They also buffer more water in the ground, contributing to the freshwater lens and reduce the potential threat of salinization and desiccation.

1.4 Impact on Poverty Reduction, Food Security and the role of Women

The gains in water access have resulted in community members no longer needing to buy water from neighboring villages in the dry season and have plentiful water access at times of no-rain for consumption, domestic and agricultural purposes. More plentiful water access during the dry season has allowed for women villagers to start growing vegetables for home consumption and also for selling at very localized level between households and sitios, locally grown vegetables have contributed to the school feeding program in the villages, generated small scale economic activities at most localized level and may be a contributing factor in reducing the malnutrition rates of Malawig and Tara villages, which prior to the project start were the highest in Coron municipality. At least 144 households in Tara and Malawig are engaged in backyard and container gardening and demonstration farming. Vegetable farming was rarely practiced when water was scarce in these communities.

Moreover, with the convenient access to water, at least 100 women weavers have more time in pandan handicraft production which help augment household income up to 100%. These women used to fetch water and do their laundry in open dug wells which are situated in close proximity to their homes.

2. Opportunities based on risk evaluation and climate assessment of three other areas.

Besides the evaluation of existing 3R measures in the Coron area Cordaid organized a workshop which brought together participants from different areas of the Haiyan corridor as well as Surigao del Norte province. Participants came with the intention to evaluate and asses if 3R technologies and the catchment approach could provide implementable options to address climate change. Clear opportunities for the potential implementation of 3R measures were found. Often, a catchment approach to water resources development strengthens the effect of these measures. In other situations, the catchment approach has less purchase. As will be seen below, both Bantayan Islands Group in Northern Cebu and Guiuan in Eastern Samar have an open underground geology (karst or limestone) which in the case of Bantayan Island Group leads to total infiltration or evaporation of the available rainwater. In such circumstances the underground flow needs attention and options come in the form of land and vegetation interventions that reduce the speed of the of the recharge but make it last longer. The presentations will be attached as a separate file to this document.

2.1 Risks and opportunities for Guiuan Eastern Samar province

Typhoon Haiyan made the first landfall in Guiuan and destroyed the already fragile watershed, denuding it of trees and eroding more underground channels in the karst ground. As the area's population increased more trees are cut. Slow onset events such as sea level rise impact continue to threaten the water resources.

General climate scenarios include:

- Average of increase of mean temperature by +1.0 to 1.1C within 6 months annually from March to August by 2035 (RCP 45)
- Recorded Heat Index in May 2019 of 33.8C with baseline of 28.0C (PAG-ASA record)
- Guiuan will have the drier months by March to May and July to August with average precipitation decrease of -11% rainfall
- Average increase of precipitation by 6 months with wettest period of 3 months from November to January
- Projection (81 years – end 21 century) 0.24 cm or 0.7 inches yearly increase or 20 cm approximately within the 81 years end of 21st century (Year 2100) under the worst climate scenario
-
- **Specific Issues based on water vulnerability analysis (2019)**
- Topographical, hydrological, climatic and soil conditions result in large variations in the availability of water
- Social: Household cost for water and food preparation of a 4-6 person per family will have estimated cost or spending to secure water supplies per month of Php 750.00 and Yearly cost of Php 9,000
- Water security and efficient management of water resources
- Water supply instability
- Every three years, Guiuan experiences a deficit in rainfall.
- Water availability is heavily dependent on annual rainfall and with saline soil formations

- Guiuan investment priority on water infrastructure, water solutions policy and involvement of
- 72% of Guiuan population dependent on mainland communities comprised of 41 villages with total population of 40,394
- 29% of island communities comprised of 19 villages with population of 15,806
- Total of 56,200 population of Guiuan

Issues

The team identified the increased of sinkholes and flooding as major issues related to climate change and water. The issue of flooding relates to the increase in wet season rainfall intensity whereby rainfall of months comes in weeks. The increase in sinkholes can be connected to this issue. When additional runoff gets into the underground it dissolves more limestone. Increasing torrential rains combined with deforestation and increased agriculture make rainwater run off faster or recharging at higher volumes.
Besides the sinkholes, population increase, and uncontrolled groundwater exploitation also leads to over extraction, particularly when no recharge takes place and water starts to run to the ocean too quick due to deforestation. Combined with sea-level rise and over abstraction of water resources this leads to saltwater intrusion. In many of the water distribution points water is now too salty for human consumption

Reflection

The proposition of recharge solutions requires more direct analysis since the above ground runoff creates more erosion and the belowground waterflows can create more sinkholes. Recharge needs to be looked at with caution because this might increase sinkholes. Interventions can therefore only come in two forms until it is clearer how the karst responds to the increase in recharge.

The first: The increased rainfall due to climate change (CC) requires an environmental Intervention that slow down the runoff *and* the infiltration. This means a less permeable layer needs to be placed between the rain and the karst. Such a layer can be of vegetation, topsoil or organic material, meaning more forest cover, more organic matter in the soils and more wetland areas. Further, existing areas of high erosion need to be understood better, particularly areas with thicker overburden (topsoil) can see more recharge measures since the speed of infiltration will be a lot lower here than in areas with thin topsoil.

Sinkholes provide two problems, one for the people around them and second for the increased drainage of the water. People have resorted to dumping rubbish in the sink hole, which will have negative impact on the groundwater quality. However, finding means to block the sinkholes will slow down the loss of water to the sea. Sinkhole areas should be protected to avoid contamination and allow environmental recovery.

Water storage interventions (Retention) make a lot of sense in this situation. Harvesting water before it gets in contact with the salty underground water or creates sinkholes will be an absolute 'do no harm' measure. Potentially this can take the form of water tanks of various sizes and shapes, ponds with impermeable layers and small retention dams.

2.2 Risks and opportunities for Bantayan Island Group (Northern Cebu Province)

General climate scenarios include:

- Extended hot months by 2050s, from May to September; April to October, with estimated increase of mean temperature by +1.5 C by the end of 2050s with up to 65% increase in number of days above 35°C 2020 to 2050.2
- Estimated reduced precipitation of up to 10% between February and April, resulting in a "dryer" dry season in 2050s
- The SLR in the Philippines is projected to increase and exceed the global average SLR. The increase is expected to be approximately 20 cm by the end of the 21st century under the worst climate scenario (PAG-ASA, 2018). MSL trend is increasing and projected to rise at 1.74 mm per year. (VSU-ICSC, 2019)

Specific issues:

Specific Issues from Climate Risk A (2019)

- Negatively impacting water availability, food security, and livelihoods).

Rapid onset flooding of low-lying areas between June and August as a progressive risk in 2020 and 2050.[3]Salinization of water as a result of sea level rise and over-exploitation of water resources. (VSU-ICSC, 2019).

- Salt water intrusion in deep wells and residences results in damages to crops and loss of livelihood and income, respectively. These effects make coastal communities highly vulnerable, particularly in times of extreme events exacerbated by climate change (VSU-ICSC, 2019)
- Coastal communities and small islands that are exposed and sensitive to and because of their relatively low capacity to mitigate and adapt, thus making them highly vulnerable to SLR (VSU-ICSC, 2019)
- Lack of recharge water (dried up dug wells and deep wells) because of decreasing rainfall and increasing temperature (BIG Problem Tree Analysis, April 2019)

Based on the team assessment everything in Bantayan Island Group revolves around the decreasing freshwater lens and its pollution because of the massive agri-industry (poultries and piggeries). The whole island depends on it and problems are starting to increase. Almost everywhere the wells are getting deeper. The following list of issues was mentioned by the participants

- Because of the increasing population, demand by energy sector for electricity, influx of tourist and the poultry and piggery (agri-industry) there is high demand of water resulting to over extraction of ground water.
- Wells are getting deeper and deeper every year which will soon lead to saltwater intrusion

[2] Cebu Province Suitability Mapping
[3] Ibid

- Chicken farms and pit latrines also occupy the recharge area, leading to groundwater pollution. The chicken farms are said to produce average of 2,000,000 eggs per day for the province of Cebu hence for the islands quite a massive industry
- Sea level rise, aggravated by over abstraction of water from the wells, leads to high risk of saltwater intrusion

Reflection:

This situation was already known in the 1990s, before the egg industry started to develop at scale and before typhoon Haiyan further destroyed the catchment.[4] This testifies to the fact that water resources management is not taken seriously. Thousands of people continue to rely on expensive water from elsewhere as more hotels and egg farms are built. The projected climatic changes problems with water resources will be severely accelerated by these developments. The obvious solution will be a water resources master plan, enforced by quota and additional cost for industrial exploitation. Additionally, interventions to add to the resource base can come in two forms.

The first: in the designated recharge area there is 32 hectares of wetland with stagnant surface water that tends to evaporate before it gets a chance to recharge the underground. A hydrological study should be undertaken that looks at recharging the water deep into the freshwater lens that would otherwise evaporate. So called managed aquifer recharge systems are known in 3R and in other areas inject fresh water into arsenic or saline groundwater, creating its own bubble. The study needs to consider the ecological consequences of the recharge.

Like in Guiuan, sinkholes allow water to flow away from the island. Finding means to block and protect the sinkholes will slow down the loss of water to the sea as long as it does not happen with rubbish or pollutants.

Water storage interventions (Retention) makes a lot of sense. Harvesting water before it gets in contact with the salty underground water or creates sinkholes will be an absolute ‘do no harm’ measure. Potentially this can take the form of water tanks of various sizes and shapes, ponds with impermeable layers and small retention dams.

2.3 Risks and opportunities for Gigaquet and Claver, Surigao del Norte

General climate scenarios include:

[4] Angus P.M. Jr and D.T. Jaque 1996 “Bantayan Island water resources study “*Transactions on Ecology and the Environment vol 12*

- Increased temperature / dry spells
- Varying quantity and intensity and timing of rainfall patterns
- Sea Level Rise
- Increased intensity of tropical storms and cyclones

`Specific issues
- Flooding
- Pollution
- Water Contamination
- Poor Water Quality
- Prolonged and increasing frequency of Dry Spells affecting most upland agriculture / rain fed farms
- Intrusion of saltwater in low-lying farms

In Surigao del Norte the threat of increased torrential rains and sea level rise aggravates compounding factors such as catchment destruction by open pit / strip mining, kaingin (among IPs), charcoal burning, quarrying in the river and logging.

In this area two municipalities sharing one upper catchment where these destructive activities take place and there is high risk of complete degradation. This leads to catchment related climate induced problems like high rainfall intensities that will destroy the downstream areas with a large area of rice paddies and settlements. Already floods in 2018 destroyed a new bridge structure. Other factors include the pollution of drinking water from the wells. Flooding due to high runoff from upstream as well as local runoff and ponding creates unhealthy circumstances and evidence of increased Bilharzia. Another is the improvement and management of the irrigation system drawing water from the same river.

Reflection: rampant catchment degradation combined with climate change impact is a recipe for disaster. In this area a catchment management organization needs to come in which monitors the mining in the upper catchment and if possible, seeks to find solutions with the mining companies to reduce the impact. Also, to impose effective enforcement of laws to prohibit / reduce logging, quarrying, and kaingin.

Potential interventions should come in the form of catchment or ecosystem based 3R which means that the upstream degradation needs to be replanted with soil conservation species. This means environmental engineering to protect the landscape against climate change induced problem. Simple water traps as above will further reduce the speed of the water and thereby decrease the flooding. The downstream interventions should look at retention of rainwater, storage reservoirs from the roofs, ponds etc. In area where flooding cannot be controlled residents might look at simple recharge pits which lead the water to the underground. (see pictures above)

3. The 3R and watershed method compared to other possible options.

The evaluated 3R solutions come out strongly when compared to other potential options for water resources management. As the program focusses specifically on remote coastal communities or islands, off grid solutions to increase the water resources make sense. Particularly if these solutions come in the form of simple small structures that local volunteers or masons can work out. They compare favorable to the following alternative options

3.1 Reverse osmosis

One of the alternative options suggested for Bantayan island was the use of reverse osmosis for drinking water supply taking in brackish water. This option has a number of advantages:

- The supply of water is guaranteed; there is plenty of sea or brackish water to turn into fresh water.
- The producers can guarantee the quality of the water.
- There are no seasonal variations in the supply

Disadvantages to reverse osmosis include:

- If not diluted properly there is risk of pollution of the environment with salty brine from the installation creating higher concentrations of salt in the underground.
- If properly diluted the system wastes a lot of water to produce drinking water. In areas with scarcity of water resources this will negatively impact the resource base.
- High cost and energy use, only the rich will benefit
- Requires high technical skills in operation and maintenance.

In some cases, for instance for companies in the tourism industry the use of reverse osmosis might be an option. For coastal communities the option was rejected.

- The cost of water would press hard on the island communities, people do not just need a few liters for drinking, they also require water for cooking, washing and bathing as well as their animals.
- Skills for operation and maintenance are lacking, particularly in remote islands
- People depend on the underground and marine resources in their direct environment, polluting these with salty brine would negatively impact the groundwater and the marine ecology

3.2 Pipelines using intakes from further away

connected to distribution tanks.

In several coastal communities a pipeline system to provide water to users several kilometers away was proposed. In Buena vista for instance, this system provides water to the town proper.

The advantage of this system is that:

- People need to put less effort into resources development, (carrying stones or terracing or planting trees)
- The system can be governed externally and become a paid water user system

In evaluating this alternative, the following needs to be taken into account

- On many of the islands alternative spring sources might not be present.
- The spring sources might suffer the same seasonal variations
- Increasing numbers of users has been known to increase the vulnerability of the system. For instance, over abstraction or system failure will impact all the people who use the spring, rather than a smaller local community who will know how to fix the issue.

In general, more variety in systems and locally managed small-scale systems will be more robust to withstand the consequences of climate change.

3.3 Surface water storage for larger distribution systems

Technically this can still be considered a retention system and thus within the 3R system. However, 3R in island communities looks more at small scale interventions. Basic advantages of large storage include

- High volumes of water during the wet season
- Opportunities for central management
- Requires management and catchment protection

The problem with this type of system is:

- Usually the geology and the landscape does not allow large storage.
- Surface water is easily contaminated and evaporates, creating unnecessary losses

3.4 Water purification

The distribution of ceramic or chemical water filters to allow purification of contaminated water.

- The main advantage of such systems is that they can be owned and maintained at household level
- It reduces the need for people to buy water since they can rely on local water availability.

- The disadvantage of this system is that most filters, accept these with reverse osmosis, cannot filter out salinity
- A filter depends on the same resources as domestic water used for washing or bathing. If the resource is depleted the filter will also not help
- Success rates with sale of filters have been very low amongst poorer communities.

4. 3R as contribution to the SDGs and SFDRR

This section further places 3R interventions in a wider context of the SDGs and the Sendai Framework for Disaster Risk Reduction.

4.1 SDGs

The 3R solutions contribute to SDG targets, particularly target nr 6: *Ensure availability and sustainable management of water and sanitation for all*. 3R solutions do not primarily respond to sanitation issues, however, 3R solutions address the quality and quantity of water resources, allowing more people to access clean water sustainably. When looked at the specific targets under SDG 6 we can see how 3R solutions at watershed level contribute to targets

6.1
By 2030, achieve universal and equitable access to safe and affordable drinking water for all: One of the prerequisites of this target is the availability of water resources. Many islanders depend on expensive water from the mainland in the dry season. Increasing the water resource availability will make target 6.1 possible
6.4
By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity: As a rule, 3R aims to increase water resources and thereby addresses water scarcity, making more water available for people suffering from water scarcity.
6.5
By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate: 3R technologies are a vital part of IWRM, often allowing different stakeholders to use the same resource more sustainably. Particularly at catchment level 3R solutions aim to increase water availability for the upstream users while providing a steady dry season supply and reduced flooding downstream.
6.B
Support and strengthen the participation of local communities in improving water and sanitation management. Typically, the kind of 3R solutions piloted and proposed allow local communities to take control over their own resources and understand the limitations of their natural environment

As we have seen in the preceding chapters, the 3R and watershed solutions make it possible to address the adverse effects of climate change thereby contributing to SDG 13, climate action

13.1

Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. See above, all the different effects of climate change that affect the islands discussed can be addressed partially or completely by 3R interventions at watershed level
13.B
Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities. The above mechanisms have been adopted by migrant and IP communities in remote islands. Solutions typically benefit women equally as men and youth since the proposed solutions allow people to take control over their own resources.

4.2 Sendai Framework for Disaster Risk Reduction

The SFDRR looks at a variety of targets that mitigate the impact of disasters on communities:

- Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality rates in the decade 2020-2030 compared to the period 2005-2015.
- Substantially reduce the number of affected people globally by 2030, aiming to lower average global figure per 100,000 in the decade 2020 -2030 compared to the period 2005-2015.
- Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030.
- Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030.
- Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020.
  (f) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this Framework by 2030.
  (g) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030.

Without going into the specifics, it can be seen above that the 3R solutions presented address these targets from one of the most critical issues in coastal and Island communities: the drinking water situation. Furthermore, the actual interventions target both the drinking water situation and the general resilience of the landscape to reduce the impact of climate disasters. This means for instance that measures to reduce erosion or high runoff serve to increase the groundwater table but at the same time reduce the opportunities for downstream flooding and landslides. In normal years these measures create an additional positive impact of increased potential for agricultural production.