Drinking-water under a "One Health" lens

Quantifying microbial contamination pathways between livestock and drinking-water

PARTICIPATORY HAZARD MAPPING

11TH JULY – 17TH OCTOBER, 2018

Draft Final Report
Version 2
June 2019

OneHealthWater Consortium

UNIVERSITY OF Southampton

VIRED

University of Brighton

Table of Contents

Abbreviations

VIRED: Victoria Institute for Research on Environment and Development

KEMRI: Kenya Medical Research Institute

MRC: Medical Research Council

Suggested Citation

Okotto-Okotto, J., Yu, W., Thumbi, S. M., Kwoba, E., Wanza, P., Gomes da Silva, D., Wright, J. (2019) *Drinking-water under a 'one health' lens: participatory mapping final report*. VIRED International, Rabuour, Kenya.

1. Introduction

Participatory mapping is a community mapping tool that has been successfully used for many different purposes, all over the world, especially, for natural resource management and to collect spatiotemporal indigenous and cultural knowledge and to spur simple intervention activities for community development. It is a general term used to define a set of approaches and techniques that combine the tools of modern cartography with participatory methods to represent the spatial knowledge of local communities. It is based on the premise that local inhabitants possess expert knowledge of their local environments that can be tapped and expressed in a geographical framework which is easily understandable and universally recognized to spur self-awareness and mitigation initiatives in the landscape to secure water sources. This approach has been used to develop hazard maps in a project known as "*Drinking Water under a "OneHealth" Lens: Quantifying Microbial Contamination Pathways between Livestock and Drinking-water*" (MRC Ref: MR/PO24920/1 Ergo ref: 31554), referred to as the "*OneHealthWater Project*" which was carried out in ten (10) villages in Asembo area of Siaya County in Western Kenya.

The participatory mapping aimed at using spatial experience-based knowledge of the beneficiary communities to identify locations and potential pathways of hazards to water sources in the neighbourhood. It was designed to help identify hazards for the water sources which could compromise safety of drinking water in the villages, and graphically display the hazards using simple maps that can spur preventive actions. The value of such data goes beyond the simple description of the variables, since they are obtained directly involving stakeholders and thus ensuring legitimacy to the process and its outcomes. They can therefore serve to sustainably reduce the vulnerabilities that pose risks to life in the neighbourhood within the community and can be of great value in drinking water safety planning for the community. In this context it is hoped that the results of the hazard mapping will allow embedded spatial knowledge to be formalised according to an approach that facilitates its integration into the management discourse, thus empowering stakeholders' participation in drinking water management.

The exercise generated data and insights concerning water safety, contamination hazards, and community use of different water sources for drinking. The communities successfully mapped the water sources that they use and contamination hazards in the surrounding landscape. The exercise was carried out in the villages by the local communities in partnership with Victoria Institute for Research on Environment and Development (VIRED-International), Kenya Medical Research Institute (KEMRI), University of Southampton and University of Brighton between the 11th of July and the 17th October, 2018. This report presents the results of the exercise.

1.1 Objectives of the Participatory Hazard Mapping

The objectives of the exercise were as follows:

- To identify and participatorily map all water sources in each of the village
- To identify and map all the hazards that could potentially contaminate the water sources

2. Organisation and Approach

A protocol describing a step-by-step procedure of the entire process together with a consent form were prepared and submitted for ethical approval. Base maps were acquired to assist participants at the meeting in putting their knowledge of the village in a geographic framework that could be later be digitalized and integrated with other data streams in the project for further analysis. Hard copy image maps were prepared from high spatial resolution satellite imagery for each village using ArcGIS 10.5. WorldView2 base map imagery, acquired on 2nd March 2013 with a spatial resolution of 0.5 metres and horizontal accuracy of 10.2 metres was used in all villages. All the image maps were enlarged to “A1” sized heavy grammage paper to present a near-reality framework and give the participants sufficient space to write and draw.

With these image maps secured, a series of discussions were held among the project team members to define, clarify the objectives and nature of the mapping exercise. Criteria for selection of participants was developed to ensure that only participants that would most effectively meet the objectives of the exercise were invited. The criteria targeted members of the community who were known to be knowledgeable, had interacted with the environment of the neighborhood at a mature level for a minimum of 10 years and were literate enough to conceptualize and establish the locations and spatial distribution of the water sources and contamination hazards. It also targeted people engaged in water and livestock management in the households. Prior to the participatory meetings, the lead facilitator held consultative briefings with the mapping team to brief, discuss and clarify the protocol and roles that each person was to perform during the sessions. The mapping team consisted of a lead facilitator from VIRED, two assistants from KEMRI and one Note Taker from within the community supported by the project team.

Table 1: Sample size determination

Village Name	Village Code	Population	Referral Sample	Sample Size
Kaminogedo	10	1435	36	15
Ndwara	13	1853	34	12
Ong’ielo	2	1245	37	16
Lwak	28	1182	39	18
Sinogo	35	408	31	13
Sangla	49	1477	37	15
Wang’arot	53	792	33	12
Siger	55	1737	35	15
Rambugu	67	519	32	12
Got Bondo	68	488	30	12
Total		11,136	344	140

Since the population was relatively homogeneous, both purposive referral and randomized probability sampling approaches were employed in the selecting the participants to be involved in the mapping exercise. On the basis of KEMRI’s previous engagements with the 10 villages, the KEMRI team helped with the identification of community guides and mobilizers. The team worked with these guides and mobilizers to select participants from each of the 10 villages. Through their ongoing longitudinal studies in the sample villages, KEMRI use a system of village reporters to liaise with and mobilize the communities. The Village reporters and guides, with the support of chiefs and village elders, proposed a list of at least 30 people from each of the villages who met the criteria that the study team had set for them. At least 3 female and three male key informants were also identified from each village making a total of 36 proposed participants per village. Out of the initial frame of 36 people (referral sample), 12-18 participants were randomly selected for the participatory mapping exercise depending on the size of each of the villages (Table 1).

With the help of the village mobilizers, a series of sensitization and community mobilization visits to the villages was carried out in order to make personal contacts with the participants, seek informed consent and invite them to the meetings. The meetings were held at locations and during times convenient for the participants (locations such as schools and churches within the villages, during non-market days). Before the meetings started, the lead facilitated self-introductions and climate setting exercises. Permission to record the proceedings of the meeting on tapes, flip chart and note books was obtained from the participants. Participants were asked to treat any contributions made during the session as confidential to stimulate free discussions. Ground rules for the discussions were proposed, discussed, agreed upon by the participants together with facilitators to guide the deliberations.

The deliberations were designed to provoke and assess the knowledge and views of the community members on water sources in their villages and hazards that might contaminate these water sources. Participants were facilitated to identify, discuss and list the different types of the water sources, the uses of each of the water sources, ranking of the water sources in terms of their safety drinking and all the hazards in the village that could contaminate them. An experiential learning approach was used to present the background material that would enable participants to carry out the mapping tasks on their own once empowered with the knowledge.

The background material presented and discussed in the introductory deliberations centred on their perception of what a water source is and what a hazard is as well as the general geography of the village as understood by the participants. The facilitator's role was then to affirm or guide where the understanding was incorrect. Based on this interactive and experiential knowledge sharing, participants were asked to list all the waters sources in their neighbourhoods and in entire villages. After the listing was completed, they were then asked to rank them. For the ranking exercise, a simple ordinal ranking approach was explained to them and employed. The next task was then to identify and list all the hazards that they thought could potentially contaminate or actually contaminates the water sources. This was preceded by more interactive discussions around the conceptual meaning and understanding of a hazard. With this knowledge, all the hazards were identified and listed on a flip chart.

Using the knowledge built up from the experiential and interactive discussions above, participants were exposed to a high spatial resolution WorldView2 image map of the each of the villages. The facilitator reminded them of the geographic features discussed earlier, explained and assisted them to recognize them on the Image maps. Of particular interest was the recognition of a key feature like a market, a school, a church or a road or a participant's homestead on the map to act as an orientation trigger. This worked successfully in an initial orientation exercise using the hard copy image maps. Participants then went about the mages identifying and navigating between well-known map features such as other churches or schools.

Once this familiarity with the image maps was successfully achieved, the larger group of between 15-18 participants elected a smaller group of between 5-7 people that they considered knowledgeable from among them to undertake the mapping exercise. Transparencies were overlaid on each map and ground control points marked on each transparency. The groups were then provided with coloured pens and asked to identify locations on the hard copy image maps where the listed water sources, as well as contamination hazards were found in the surrounding landscape. As they progressed with the task with the larger group as observers, each of the groups discussed and agreed on each water source's or hazard's location in relation to the various topographic features that they could identify on the image map before its location was finally marked on the transparency. The exercise took 3-4hrs.

Upon completion of the tasks, the resultant hard copy maps were cartographically processed by scanning and georeferencing them using the earlier established ground control points. To optimise georeferencing for local accuracy, the spline transformation was adopted for five villages including Got Bondo, Kaminogedo, Ndwara, Sangla and Siger. In the rest of the villages a first order polynomial transformation was applied in georeferencing. On average, five ground control points were used per village for first order polynomial transformation and 51 control points were used per village for spline transformation. Water sources and contamination hazards were then manually digitised from the georeferenced images. All the notes which were taken were elaborated and anonymised.

3. Results and Discussions

3.1 Characteristics of Participants

Out of the 15-18 participants from each village that were invited to the sessions, an average of 13 (approximately 80%) of the invitees attended the meetings. The number of women in each of the groups averaged 5 and 6 respectively which was a good balance between those who are directly engaged in water management in the households and livestock in the villages. In the large group, the percentage ratio of male to female gender was 58.6: 41.4 % while in the small group, the ratio was 55: 45 % giving a good balanced between water managers and livestock managers and key informants. Table 2 presents these characteristics.

Table 2: Gender based characteristics of participants

Village Name	Large group		Small group	
	Men	Women	Men	Women
Ndwara	7	5	3	4
Sinogo	9	4	3	2
Sangla	7	8	4	3
Wang’arot	7	5	3	2
Rambugu	5	7	2	3
Siger	12	3	4	3
Got bondo	8	4	3	2
Lwak	8	10	3	4
Ong’ielo	10	6	5	2
Kaminogedo	9	6	3	2
Percentage ratio	**58.6**	**41.4**	**55**	**45**

3.2 Listing of Water Sources and Ranking of their Safety

The participants were asked to rank the safety of each of the water sources using simple ordinal techniques. During the ranking exercise, there were many instances in which participants disagreed with each within each other's opinions on the ranking of particular water source. This was more common in tail-end ranks starting from the 4th (fourth) rank going backward to the last rank. In such circumstances, a vote was sought among the participants and the majority decision was recorded as the rank of such a water source. Across the villages, there was relative high concurrence level on the ranking of Rain water. The only water sources that did not attract much conflict across the villages was rainwater (Table 3).

Participants' choices of ranks appeared to be largely influenced by economics, perceived organoleptic and visual physical properties as well as mythical considerations rather than perceived microbial characteristics of water. For instance, despite the fact that tap water from the formal supply system is treated to make it suitable for drinking, rain water was ranked ahead of the tap water as best for drinking. Probed as to why this was so, it emerged that the smell and taste of chlorine was unappealing to the community members. In their experiences, rainwater, had no such tastes, sweeter and harvested free of charge. Consequently, they would rather use rain water than tap water.

Table 3: Summarized safety ranking of the water sources by participants within and across the villages

	Tap water	Borehole	Well	Spring	Rainwater catchment	Water kiosk	Water collection point	Water pan/ pond/ put	Burst pipe
Ndwara	2	-	-	-	1	-	5	4	3
Sinogo	6	3	4	1	2	5	9	8	7
Sangla	-	-	-	-	1	-	-	2	
Wang'arot	2	5	4	6	1	3	9	8	7
Rambugu	2	4	5	-	1	3	-	6	
Siger	2	-	-	-	1	-	5	4	3
Got bondo	2	5	4	-	1	3	7	6	-
Lwak	5	4	3	1	2	6	9	8	7
Ong'ielo	1	-	-	5	3	2	-	6	4
Kaminogedo	2	-	5	6	1	3	8	7	4
No. sources mapped (%)	22 (0.75%)	4 (0.14%)	31 (1.06%)	13 (0.44%)	2,812 (96.14%)	4 (0.14%)	3 (0.10%)	3 (0.10%)	11 (0.38%)
Mean Rankings	2	2	3	2	1	4	5	6	3

The safety of rainwater is held as God given from heaven and they also don't have to spend to fetch it for use. The only investment required is the containers for fetching and storage of the water which communities do according to each one's socio-economic ability. In fact, there is a popular belief within the communities that rain water is directly from God and therefore already fully blessed and cannot cause any harm to the users **("*pi mogwedhi*")** as expressed by a participant in the blub below;

> *"Wan pi koth ok wachandre gi chwako nikech en pi moa malo ka Nyasae, ma Nyasae osegwedho chuth kendo omiyowa nono. En* ***pi ma ogwedhi*** *ma ok nyal hinyo kata ka omodhe amodha ma onge yath moro amora ma oketie. Bende omit kendo ooge kod tik kaka pi fireji"*
>
> ***Participant from one of the Village meetings***

The majority therefore do not process it further before consumption and during the wet season, it is the main source of drinking water for both adults and children under the age of 5 years.

During the discussions, the participants indicated when rain water is kept in storage for a week or so in a closed earthen pot, tiny insects would become visually notable, which is further evidence of its safety characteristics. Even though in most cases, people consume water from this source without any treatment, it was noted some basic processing really needs to be done before use. Basic processing suggested included boiling, application of "*Waterguard*" and other chlorine-based water treatment chemicals.

Spring water sources were also ranked highly as second to rain water. There were mythical perceptions that it comes from underground and is therefore cleaned thorough the soil matrix and is safe. However, human and livestock droppings are common in the immediate catchments of many of these springs, a practice which could contaminate these sources most of which, are unprotected. There is also the practice of scooping out soil or digging out the areas around the spring outlet to create a pan-like structure where water accumulates for use by both humans and livestock. It was revealed that this modification is often done to accommodate livestock use especially in the dry seasons. The practice could contaminate these water sources but humans still use them as well.

Burst pipes are ideally artificial water sources created by either too much water pressure in the piped water system leading to accidental bursts of the pipes at weak points and sometimes due to pipe quality; but takes time to be repaired. It was also noted that sometimes it is some of the errant members of the communities that deliberately vandalize the pipes in order to get free access to water as it flows in the pipes through their neighbourhoods. Communities then use these locations as a source water for domestic use including drinking. Whichever is the case, participants observed that the sanitary characteristics of the burst sites could encourage contamination of the water drawn from them. In many instances, people draw the water directly from the burst jet as it gushes out or scoop out the area around the spot to create a depression where water collects. Participants noted that some people use water from this source drinking without any treatment.

3.3 Listing of Hazards in the Villages

The participants identified and listed on a flip chart all the hazards that were perceived as potential contaminants of water sources. This was facilitated by the knowledge gained during the discussions led by the facilitating team. Sangla village (5 Hazards) and Siger village (6 Hazards) had the least number of hazards identified while On'gielo village (15 Hazards) had the largest number of hazards identified. As is notable from table 4 below, individuals seem to vary in their perceptions of themselves and the world around them, which variation is based on subjective values, frames of references, competencies and expectancies. These variables have the capacity to influence group dynamics in such a way that even though a current knowledge base could be the same, two groups receiving the same instructions can make diametrically different conclusions in the same situation. This explains why Sangla and Siger villages had the least number of hazards identified compared to the rest of the villages even though the instruction substance was held constant by the facilitators. Generally, however, animal/human wastes were the most mentioned across the villages as presented in figure 1.

Even though pit latrines were identified as a hazard in the villages, locating them on the maps proved difficult for participants due to their sizes relative to the scale of the image maps. Diffuse hazards such as dung or animal droppings or wastes were mapped by inference. For instance, grazing areas were mapped by indicating areas dedicated as grazing areas by the communities.

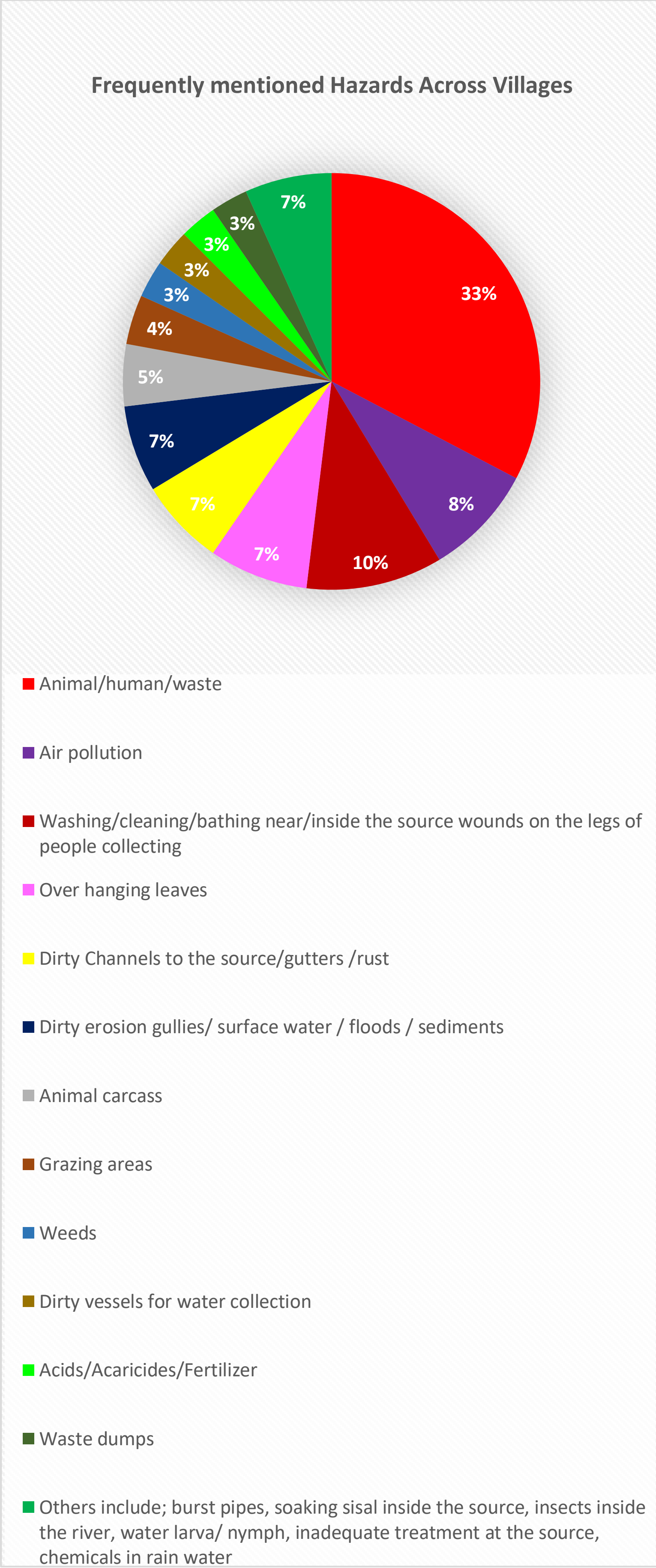

Figure 1: Frequently mentioned hazards across villages

Table 4. Listing of Hazards to water Sources as perceived buy participants in all the villages

Village	Hazards at the source or in atmosphere										Mapped landscape hazards					Unmapped landscape hazards				hazard s
Wang'rot	Wound in people collecting	Soaking sisal inside the source	Plants leaves	Animal carcass	Air pollution	Rust					Grazing areas	Pit Latrines				Open defecation	Car wash near the source	Cultivation using fertilizer near the source	Washing near the source	12
Sinogo	Animal waste	Insects inside the river	Dirty tunnels	Dust	Birds dropping	Plant leaves	Bathing inside the source	Farm equipmt cleaning			Grazing area	Pit latrines				Acaricides			Washing near the source	12
Ndwara	Birds dropping	Animal wastes	Rust	Dead carcasses	Weeds	Algae	Water larva/ nymph	Dust	Plant leaves		Animals					Human waste	Raw sewage			12
Ongielo	Dust on the roof	Tree leaves	Rust	Birds dropping	Air pollution	Dirty containers	Animal waste	Human waste	Bathing inside the source	Inadeqt treatment at the source	Grazing area	Channels to the source	Erosion/ surface water	Pit latrines	Burst pipe					15
Kaminoge do	Bare foot in pan	Human waste	Birds waste	Leaves	Dust						Domestic animal wastes	Sediments	Pit latrines			Floods	Washing near the source			10
Lwak	Tree leaves	Birds droppings	Air/dust	Human waste	Animal wastes						Grazing area		Sediments	Pit latrines		Bathing areas	Floods			10
Got Bondo	Surface running	Chemicals in Rain water	Human waste	Dead carcass/ waste	Dirty ropes for fetching water	Dirty containers for fetching water	Bird wastes	Rust	Acids		Human waste		Smoke/ cooking smoke	Pipe burst	Animal waste					13
Rambugu	Storm drains/ gullies	Dead animals	Garbage	Dust	Rust	Plant leaves	Bird droppings				Animal waste	Pit Latrines								9
Sangla	Human wastes	Bathing inside the source									Animal waste i.e. urine, dung etc.	Pit Latrines				Waste dumps				5
Siger	Storm drains/ gullies	Plant leaves	Algae	Animal carcasses							Animal waste	Pit latrines								6

3.4 The Mapping Exercise

The physical results after the participatory mapping exercise were the maps in which the participants provided their spatial experience-based knowledge on the water sources and hazards in the 10 villages in the study area. The maps are presented in the diagrams below:

a) Maps from the Participatory Mapping Process

The smaller group took charge of drawing of the maps with inputs and critiques from the larger groups using a key that was agreed upon based on the features that needed to be mapped. The raw maps from the mapping process were cartographically elaborated without any distortions to the participant's perspective thought-line to make them fit for geoprocessing activities. A sample of the raw map and the attendant key or legend is presented in the figure below for Ong'ielo Village.

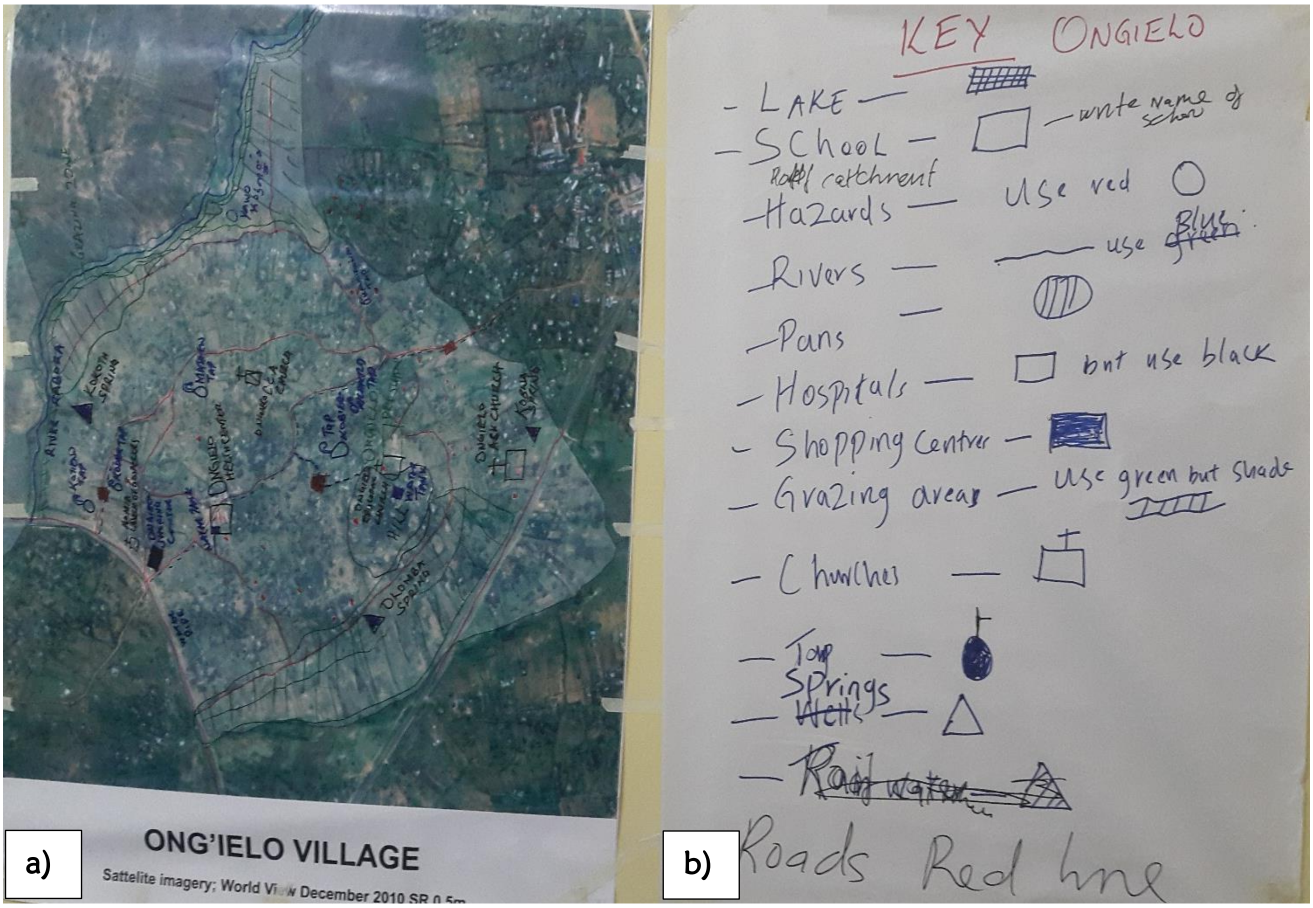

Figure 2: a) Sample image map of Ong'ielo Village overlaid with a transparent film with the community hand-drawn map and b) the key they used for creating the map

Figure 3: A sample cartographically elaborated map for Sangla Village with graticule and key improved for geo-processing

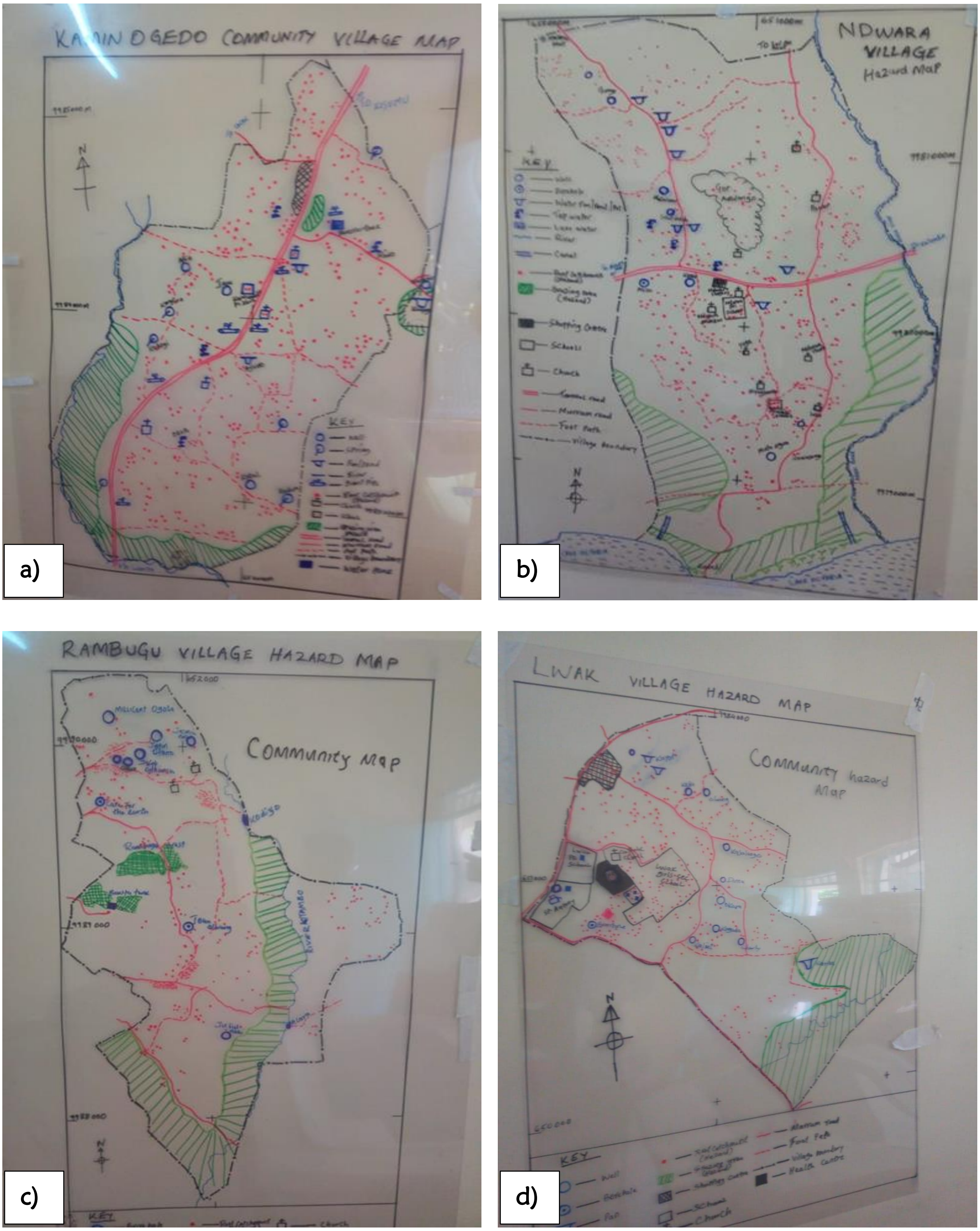

Figure 4: Sample cartographically elaborated maps of a) Kaminogedo, b) Ndwara, c) Rambugu, and d) Lwak Villages with graticule and key improved for geo-processing

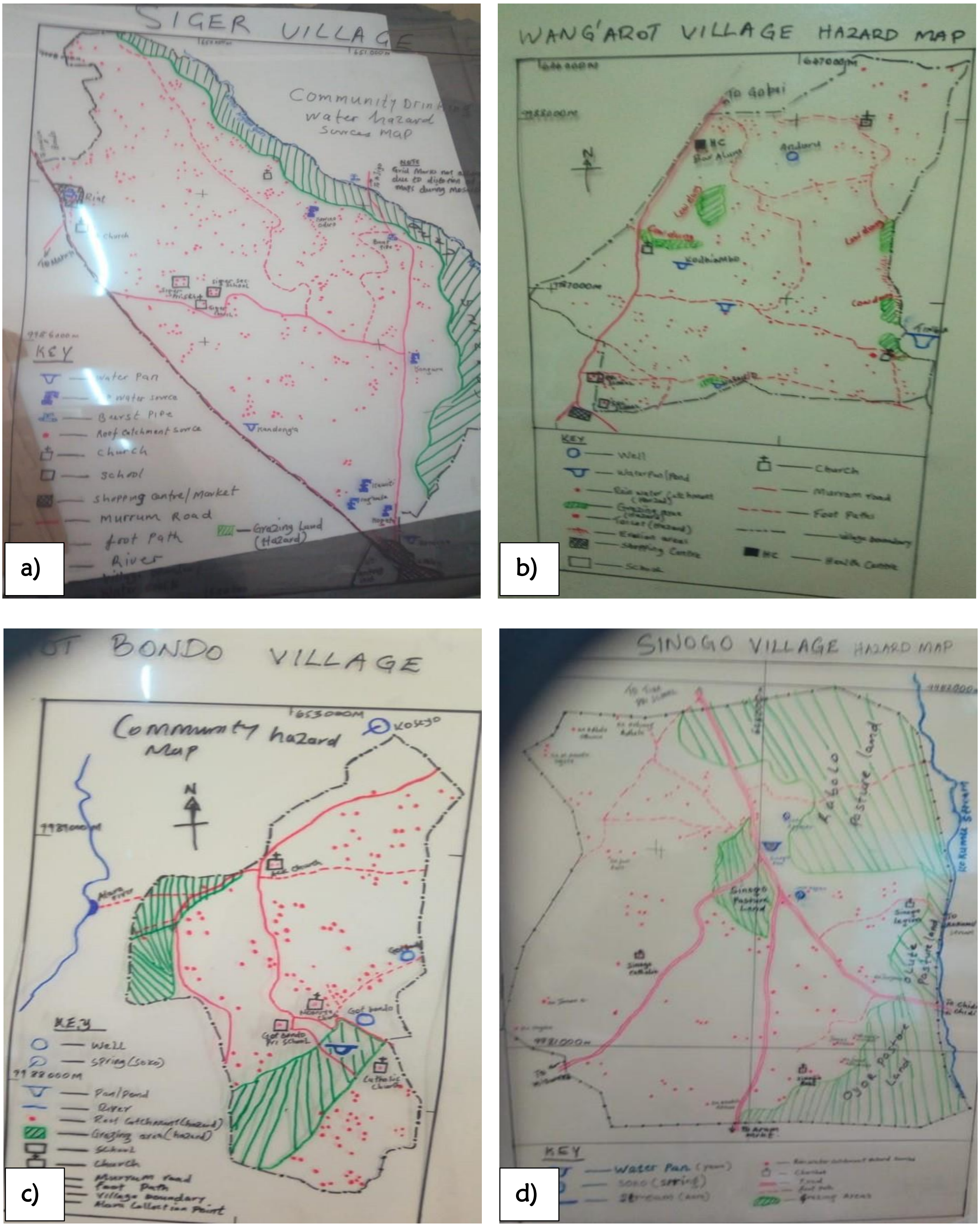

Figure 5: Sample cartographically elaborated maps of a) Siger, b) Wang'arot, c) Got Bondo, and d) Sinogo Villages with graticule and key improved for geo-processing

b) Geo-processed and Rectified Maps from the Participatory Mapping Process

In the geoprocessing of the maps, two different transformations were used for georeferencing. In some villages, first order polynomial transformations using about five ground control points on average per village were used. This yielded a Root Mean Square Errors (RMSE) varying from 0.855 to 1.756. On average, 51 control points were used per village for spline transformations, which were used in the other villages. Samples of the resultant maps are presented the figures below. The maps yielded a very rich set of spatial data sets that could be successfully used in Water Safety planning within the Village. This is because the spatial data set is a reflection of how the communities understand the spatial distribution of water sources and the hazards in the neighbourhood and effectively plan and implement measures to break and block the pathways and keep the water sources safe.

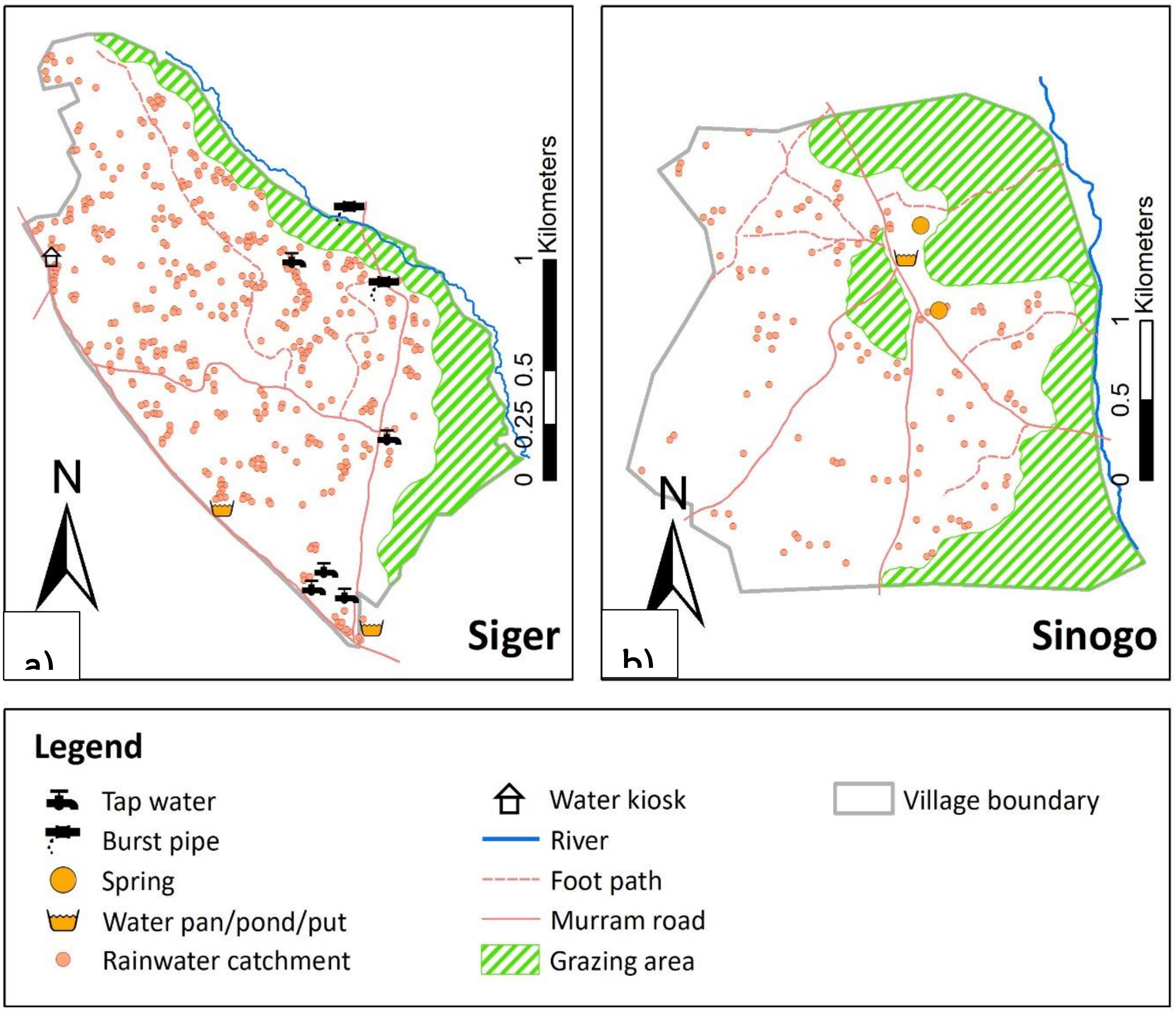

Figure 6: Computer (GIS) generated geo-processed maps for a) Siger and b) Sinogo Villages

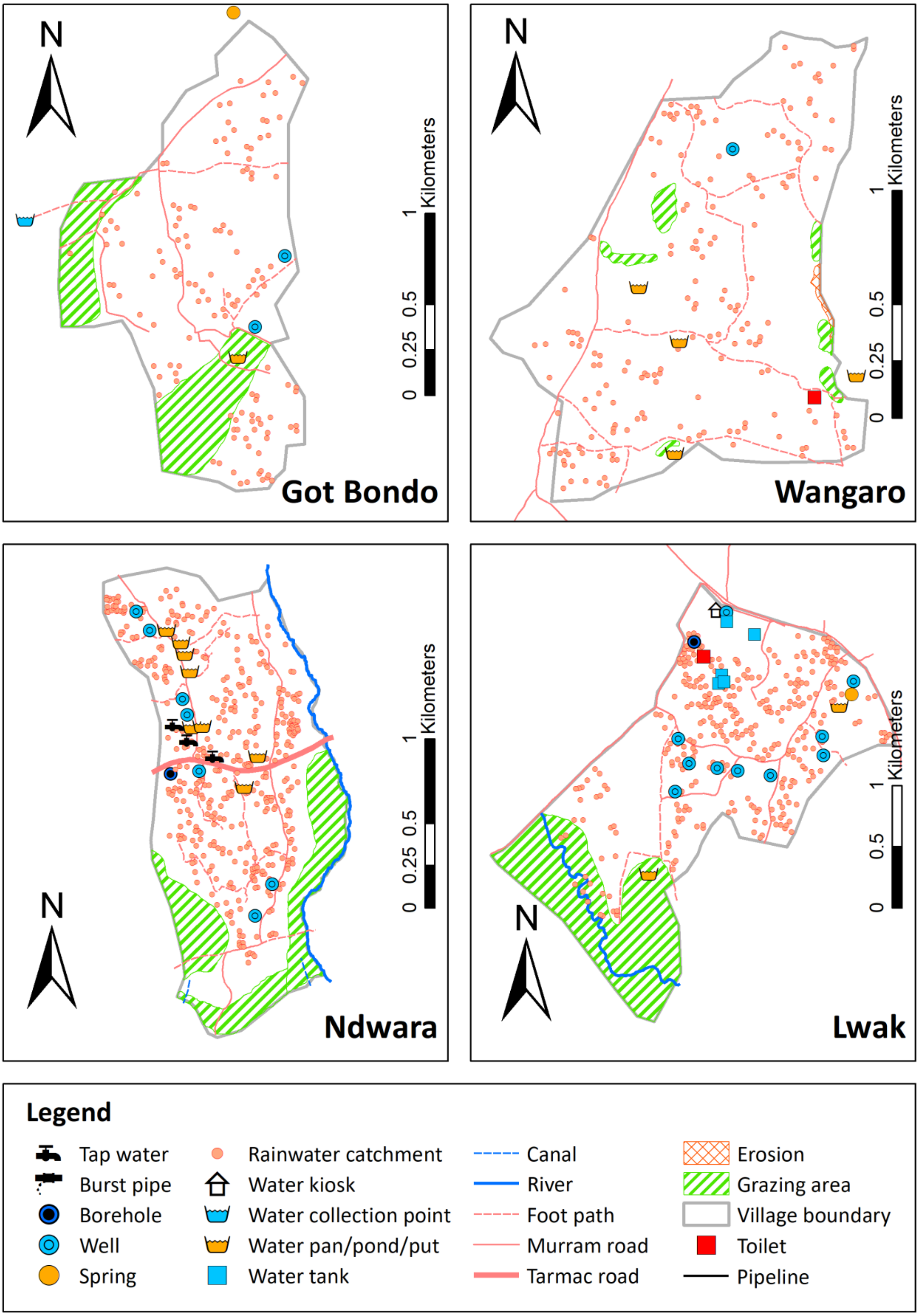

Figure 7: Computer (GIS) generated geo-processed maps for a) Got Bondo, b) wang'arot, c) Ndwara and d) Lwak Villages

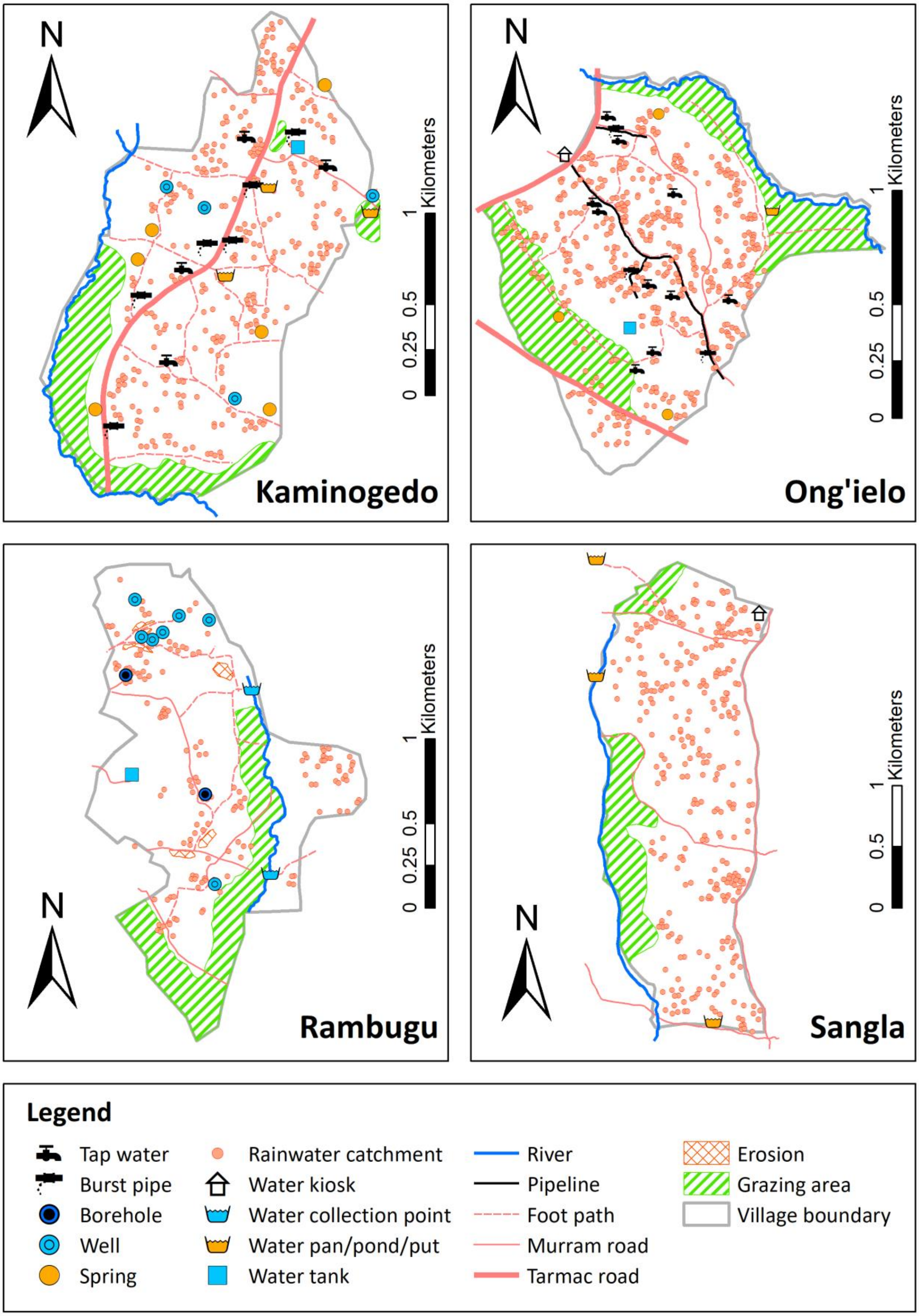

Figure 8: Computer (GIS) generated geo-processed maps for a) Kaminogedo, b) Og'ielo, C) Rambugu and d) Sangla Villages

In this regard, the value of such data goes beyond the simple description of the variables, since they are obtained directly involving stakeholders and thus ensuring legitimacy to the process and its outcomes. They can therefore serve to sustainably reduce the vulnerabilities that pose risks to life in a given neighbourhood within the community. In this regard, participatory hazard mapping could be of great use in Water Safety Planning initiatives to help beneficiary communities and project implementing agencies to identify sources of potential contamination (the hazard), develop methods to control the hazard, monitor when the supply is in compliance and verify the effectiveness of the whole system (i.e. from catchment right through to the point of water use).

4. Conclusions and Recommendations

The strengths of participatory hazard mapping as a method in helping to facilitate local people to work collaboratively with the project team to draw on their local knowledge in the *OneHealthWater* Project has successfully been demonstrated in the project. The water sources and hazards in the villages were successfully identified, listed, and mapped. Although, rainwater was ranked as the best above every other water source including piped processed water from the formal water supply system, the basis for this ranking seems to be mythical, organoleptic and physical appearance in nature rather than microbial or chemical. The perception presents a challenge because the roof catchments and the water harvesting infrastructure are not designed in a flexible way that can encourage cleaning before the onset of rainfall events. They are littered with several organic materials that encourage microbial activity, which pose a great hazard to the users of these water sources.

Generally, valuable data was collected and insights into the community perceptions of water use practices within the study villages were gained. The insights have laid a strong grounding for a follow-on project to build relationships with residents of the villages with a view to mobilizing simple interventions that could break contamination pathways and stem contamination of water sources in the villages.

There was however the limitation, particularly, that the data generated and captured may reflect only the views or mind maps of the people in the room participating in the exercise. This limitation is not unique to this study, but it is also common most in-depth, qualitative research approaches. A careful balance in the recruitment of participants and use of other data streams alongside the participatory mapping exercise which was applied in this study could however be a suitable way of addressing this limitation and validating the data. All the objectives of the hazard mapping were therefore achieved and it has shown that with further improvements, participatory hazard mapping could be used as a trigger for interventions that could improve the quality of water being consumed by village residents and as tool for corroborating information from other data streams in multi-disciplinary study.