



More than just water ! Hydraulic materiality and the process of resource making : a sociohydrological reading of Tunisian hillside reservoirs

Jeanne Riaux, Andrew Ogilvie, Zakia Jenhaoui

► To cite this version:

Jeanne Riaux, Andrew Ogilvie, Zakia Jenhaoui. More than just water ! Hydraulic materiality and the process of resource making : a sociohydrological reading of Tunisian hillside reservoirs. *Journal of Rural Studies*, 2020, 79, pp.125-135. <10.1016/j.jrurstud.2020.08.041>. <hal-02929493>

HAL Id: hal-02929493

<https://hal.science/hal-02929493v1>

Submitted on 24 Aug 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY-NC-ND 4.0 - Attribution - Non-commercial use - No Derivative Works - International License

More than just water! Hydraulic materiality and the process of resource making: a sociohydrological reading of Tunisian hillside reservoirs

Jeanne RIAUX^{a,d,*}, Andrew OGILVIE^{a,b}, Zakia JENHAOUI^{c,d}

^a IRD, UMR G-EAU. AgroParisTech, Cirad, IRD, IRSTEA, Montpellier SupAgro, University of Montpellier. 361 rue J-F Breton, BP 5095, 34196 Montpellier cedex 5, France.

^b Department of Geography, King's College London, WC2R 2LS London, UK.

^c French Research Institute for Development (IRD), IRD, BP434, 1004 Tunis, Tunisia.

^d INAT, National Agronomic Institute of Tunisia, 43 Avenue Charles Nicolle, 1082 Tunis, Tunisia.

* Corresponding author: **Jeanne RIAUX**, jeanne.riaux@ird.fr

E-mail addresses:

jeanne.riaux@ird.fr, Andrew.ogilvie@ird.fr, zakia.jenhaoui@ird.fr

More than just water! Hydraulic materiality and the process of resource making: a sociohydrological reading of Tunisian hillside reservoirs

Highlights

- Interdisciplinary field research reveals the multiple functions of hillside reservoirs
- Tunisian hillside reservoirs are unreliable hydrological and economic resources
- Hillside reservoirs support a process of relational resource making
- Sociohydrological negotiations yield new insights into water-society relations

Abstract

Fulfilling both “Water and soil conservation” and “Integrated rural development” objectives, hillside reservoirs are very popular components of water and/or rural management strategies. In Central Tunisia, more than 800 reservoirs have been built since the 1950s. These have been the subject of an abundant literature by both social and physical scientists. However, this literature, which is highly segmented and often centred on the technical and economic assessment of development programs, does not help understand the different logics at work in the appropriation of these technical objects by the different actors involved.

To achieve this goal, our research based on a "sociohydrological negotiation", articulates the methods and research questions of hydrology and anthropology on a same case study in Central Tunisia. An initial survey of water use and management practices around hillside reservoirs in the Merguellil Catchment revealed the wide variety of the infrastructures and the multiple functions they fulfil. These initial observations underpinned the process of negotiating an interdisciplinary framework to analyze the social, physical and technical dimensions of hillside reservoirs.

To trace the history of watershed development policies implemented in the Merguellil Catchment, we first examined the multiple embedded logics underlying Tunisian hillside reservoir planning. This led to the production of “sociohydrological narratives” for four hillside reservoirs that both combined and enabled us to analyze the inhabitants’ own accounts of their reservoir history. This ethnographical material was then examined through the lense of a “resource making process”. Considering the way in which hydraulic objects function in a landscape that is both socio-political and hydrological enabled us to analyze the different aspects of this resource making process, from water valuation to the production of “hydraulic localities”.

Key words: Water, small reservoirs, hydraulic locality, resource making, Tunisia.

1. Introduction

From the 1930s on, soil degradation and erosion became pressing issues worldwide. These problems were mainly tackled through anti-erosion initiatives, as shown in the works of Bennet (1939), the so-called “father of soil conservation” (Roose et al., 2010). Hereafter, rural development programs often included a “water and soil conservation” component. Such programs rely on different types of hydraulic structures designed to limit erosion, gullyng and silting up of downstream dams. Some are designed to reduce and slow down runoff, while retaining the soil by creating benches or ridges made of stone and vegetation. Others aim to “trap” the sediment in structures positioned around the catchment, which is the case of hillside reservoirs. Huge spaces of this type have been created around the world, particularly in Mediterranean regions, as these are considered particularly vulnerable to land degradation.

As water and society are both deeply rooted in mutually shaped relationships (Casciarri and Van Aken, 2013), introducing hydraulic infrastructures in a landscape will inevitably affect both ecology, the organization of social groups and water/society relationships. The abundant

scientific literature on hillside reservoirs in both social and physical sciences, testifies to the difficulty of grasping their implications in a given area. This literature is highly segmented, and separates physical (hydrology and soil sciences) and social approaches in two very distinct worlds of thought, with little communication between them, as is often the case for water and more generally for “natural resources” (Mosse, 1997; Baviskar, 2003; Bakker and Bridge, 2006). On the one hand, hydrologists and soil scientists focus their attention on how physical processes such as erosion or runoff are affected by the construction of benches or reservoirs: their analyses focus on how to better control the natural flows of sediments and water. Their research questions therefore focus on the "how": the positioning and dimensioning the works, sediment flows, runoff and water infiltration is influenced (i.e. Baccari et al., 2008; Zucca et al., 2015). This research can be viewed as the scientific counterpart of hydraulic development policies, in which water and soil are considered as “resources” to be developed in the most efficient way. On the other hand, social scientists focus on the economic, political and social aspects of water and soil conservation. The vast majority of their studies focus on hillside reservoirs, also known as small dams, which are the most visible developments, and whose particularity is to be able to store water, and therefore to enable hydro-agricultural activities. These studies focus on three main aspects. First, the economic potential of the reservoirs for productive activities including agriculture, fish farming, watering livestock, and leisure activities (i.e. Cecchi, 2007). The main entry is, however, agricultural water management, in line with the productivity function of hydraulic development planning (i.e. Mugabe et al., 2003; Ashraf et al., 2007). The second way of considering the social dimensions of reservoirs concerns how people organize activities and distribute water and/or land rights (Mosse, 1997; Sally and Levite, 2011).. The third approach focuses on water policy analysis. Social scientists highlight the logics behind development choices and their social and political consequences, particularly problems linked with corruption (Venot et al., 2011; Venot and Hirvonen, 2013).

Many authors have also focused on the difficulties and conflicts associated with the creation of water users associations, which is the institutional component of watershed development programs (Mosse, 1997; Aubriot and Prabakhar, 2011; de Fraiture et al., 2014). Finally, a very small corpus of research literature highlights the way in which hydraulic infrastructures are set up as “symbolic resources” (Mosse, 1997).

This last approach, focused on the resource making process, is particularly enlightening for several reasons that guided our analytical choices during this interdisciplinary study of Tunisian hillside reservoirs. The starting point was that dialog between hydrologists and social scientists is difficult, if not impossible, due to their epistemologically and axiologically incompatible orientations concerning hillside reservoirs, and more generally water (Wesselink et al., 2016). However, scientists must overcome both the “*dangers in an over-socialized view of natural resources*” (Mosse, 1997, p.473) and the “*presumptions contained in the term ‘natural resource’ [... where] ‘natural’ suggests an existence outside culture*” (Bavsikar, 2003, p.5053). To tackle this epistemological challenge, Valadaud and Aubriot (2019) underlined the importance for social scientists to consider the materiality of water, by adopting a sociotechnical approach to water/society relationships. Thanks to the physical structure of technical objects and the way they operate, this focus makes it possible to observe the many different functions the objects fulfil, irrespective of whether the functions are material or symbolic, physical or social (Sigaut, 2010). Here, we argue that the double entry, i.e. via the materiality of water and via the resource making process, is also a powerful way of reconciling social and hydrological analysis of water/society relationships around hillside reservoirs.

This article reports on an interdisciplinary field study in the Merguellil wadi catchment, in Central Tunisia, between 2011 and 2013, conducted by an anthropologist, a hydrologist and a technician specialized in quantitative and qualitative field data collection. This study represents a “sociohydrological” way of considering the relationships between water and

society (Riaux and Massuel, 2014; Riaux, 2019), between the *socio-hydrology* approach used by hydrologists (Sivapalan et al., 2012) and the *hydrosocial* approach used by critical geographers (Linton and Budds, 2014). Such an interdisciplinary dialog between anthropology and hydrology involves a continuous “negotiation” (Massuel et al., 2018), which in the present study, comprised four steps and is detailed below.

To trace the history of watershed development policies implemented in Central Tunisia, we first analyze the multiple embedded logics underlying Tunisian hillside reservoir planning. In the second part of the text, we present the results of our original survey of water use and management practices surrounding the hillside reservoirs in the Merguellil catchment. These initial observations underpinned the process of negotiating an interdisciplinary framework to analyze the social, physical and technical aspects of hillside reservoirs. We then present the “sociohydrological narratives” of four hillside reservoirs that combine the inhabitants’ accounts of their reservoir history. In the third section, we analyze the ethnographical material through the lense of resource making processes. Considering the way in which hydraulic objects operate in a both socio-political and hydrological landscape enables us to analyze different aspects of the resource making process, which, in turn, allowed us to analyze how a hydraulic technique is interpreted differently by different actors, leading to contradictory situations, for example, the inhabitants’ concerns about how to ensure a resource that is often considered unreliable, can be secure in the long term. The explanation of this contradiction can be found in the symbolic functions fulfilled by hillside reservoirs.

2. For what purpose are hillside reservoirs in Central Tunisia designed?

Central Tunisia is delimited to the north by the “Dorsale”, a mountain range running from the south-east to the north-east of the country (fig. 1). Known for its vulnerability to erosion caused by runoff, the upstream part of the watershed has been the subject of large-scale water and soil conservation works since the middle of the 20th century. Between Independence (1956) and

today, hundreds of hillside reservoirs have been built on the part of the “dorsale” that overlooks the Kairouan plain, including many hectares of land with anti-erosive benches (Lacombe, 2007; Ogilvie, 2015).

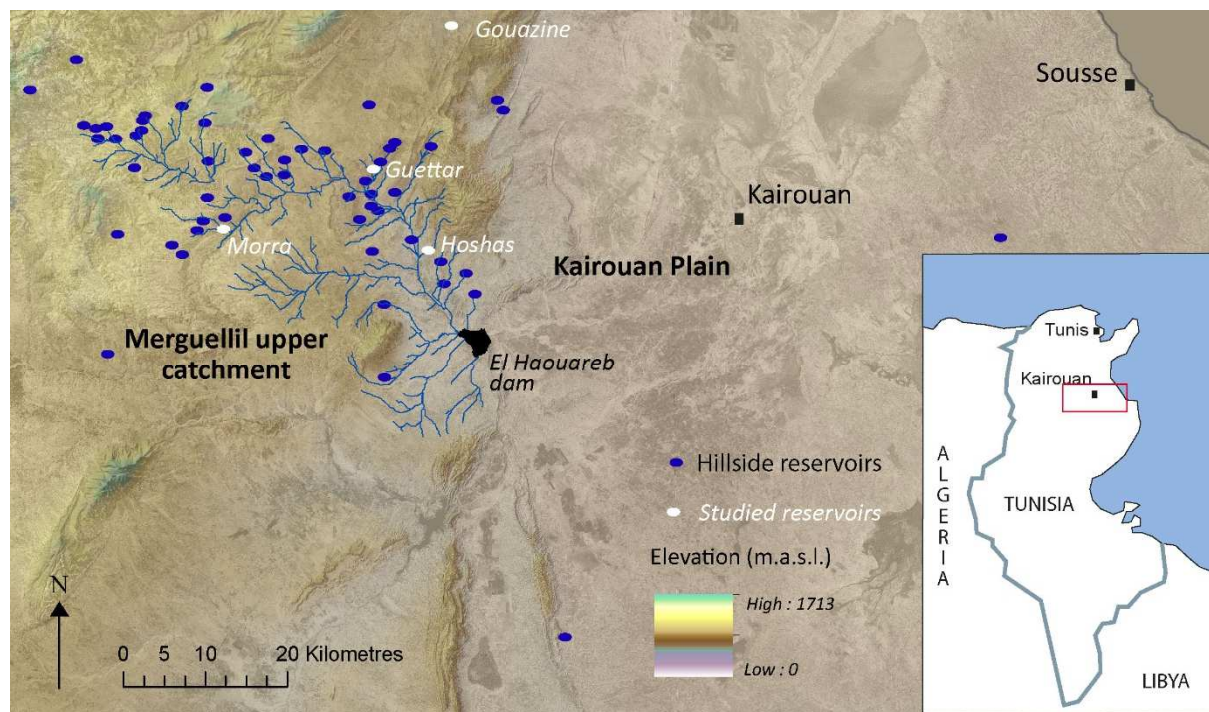


Figure 1. Hillside reservoirs in the Merguellil catchment

One stage of our interdisciplinary negotiation consisted in historicizing the development of hillside reservoirs by analyzing the various policies of which they have been a part. A review of the literature combined with discourse analysis¹ enabled identification of the goals behind the construction of hillside reservoirs. We then analyzed the overlap of several logics surrounding these technical objects.

2.1. Historical overview of watershed development policies in Tunisia

Water and soil conservation works in Tunisia began in the 1950s, first implemented by the hydraulic services of the colonial Public Works, then after Independence (1956) by the Forest Direction of the Ministry of Agriculture, until a dedicated Water and Soil Conservation

¹ The analysis is detailed in Riaux et al. (2015) and brings together ethnographic materials also collected by M. Cheikh Rouhou for her MSc (Cheikh-Rouhou, 2014).

Department was created in 1983 (Roose, 2002). In 2001, the perimeter of the Water and Soil Conservation Department was redefined, with a focus on agricultural development in rural areas, as reflected in its name: General Direction for the Development and Conservation of Agricultural Land (French acronym DG-ACTA). These developments marked a change in the way of conceiving State interventions in rural areas that is nicely illustrated by the history of watershed development policies.

Initially, the aim behind these developments was twofold. The first was to control erosion caused by runoff to prevent soil degradation. It first involved a combination of benches and anti-erosion plantations that were largely inspired by the so-called “traditional hydraulic techniques”: *meskat* and *tabia*, used in other parts of the country (El Amami, 1977; Hill and Woodland, 2003; Ouessar et al., 2004). These techniques enable non-aggressive cultivation of the soil and the use of runoff water to irrigate the crops. The techniques are promoted not only for their local valorization of water and their anti-erosion efficiency, but also for their artisanal characteristics, which meant they can be built locally, which was the second objective of these developments. At Independence, above all, this hydraulic development policy had social objectives, to promote local development and thereby reduce the rural exodus. In particular, it was a way to provide paid work for rural populations (Côte, 1964). Supported by the United Nations World Food Program, this policy has led to substantial soil conservation works. The fact social objectives took priority over technical ones has influenced the choice of areas to be developed, with priority given to social and political issues, and the technical robustness of the works (Roose, 2002). In the Kairouan region, between 1968 and 1980, hillside lakes became a complementary tool to reduce erosion and protect downstream land, leading to a Tunisian-American program funded by FAO in which 40 hillside lakes were built.

From the 1980s on, a new objective emerged in development policies: that of preventing the silting up of large dams. Here, the aim was to consider the development of hydrographic basins

as a whole, with upstream spaces serving as catchment areas to supply water for the economic development of downstream spaces, whether for large irrigation schemes or to supply towns with drinking water. This development resulted in the promotion of hillside reservoirs whose function - complementary to that of benches - is to prevent upstream sediments from filling downstream dams. This led to the idea of water conservation in addition to the original idea of soil conservation. However, it was in the framework of the national strategy for Water and Soil Conservation (CES I, 1990-2000) that its full scope was revealed with 1,000 hillside reservoirs to be constructed on the Tunisian “dorsale”. According to Berndtsson et al. (2016), more than 800 of the planned hillside reservoirs have already been built, including 55 in the upstream Merguellil basin, justified by protecting the El Haouareb dam built in 1989. These developments have mainly technical objectives, but local development is still used to justify them. In the 2000s, with the second national Water and Soil Conservation plan (CES II), social objectives regained importance. Thus, the Ministry of Agriculture’s “Kairouan Hills” Integrated Rural Development Program promotes the creation of local water resources to enable the cultivation of small-scale irrigated crops in rural areas. In the framework of a European Union development program, people living in the vicinity of the reservoirs received aid, especially in the form of motor pumps and pipes, to start growing irrigated crops. Finally, the CES II strategy pointed to groundwater recharge as an additional function for reservoirs. The only function of some hillside reservoirs today is to recharge groundwater through infiltration of their stored water. In this case, local inhabitants are forbidden to use the water.

2.2. The confusing and conflicting functions assigned to hillside reservoirs

Over the past 70 years, hillside reservoirs have been the subject of several policies, tackling problems as diverse as poverty, rural exodus, land degradation and water management. Their

history can be divided into four main periods associated with five major development goals that do not replace but rather complement one another (fig 2).

Period	1956-1980	1980-1990	1990-2000	2000-2010
Development programs	Cash for work vs rural poverty	Catchment development	Integrated Rural Development	Kairouan Hills
Expected functions of reservoirs	Soil conservation			
	Fighting rural poverty and exodus			
	Protecting dams			
	Groundwater recharge			
	Local development (irrigation)			

Figure 2. Overlapping functions assigned to hillside reservoirs

The overlapping of functions attributed to hillside reservoirs illustrates their role as “boundary objects”, as pointed out by Venot and Hirvonen (2013) following Star and Grisemer (1989) and explaining the success of these hydraulic infrastructures in which each actor saw the embodiment of their own objectives.

However, this analysis explains but does not get round the fact that contradictory functions are attributed to hillside reservoirs. The most visible contradiction lies in the way of defining the location at which the water should be valued. Rural development policies promote local use of water, particularly for agricultural development. The hillside reservoirs are then explicitly considered to be a tool for local development, targeting the people who live near the reservoir. Conversely, watershed development aims to control hydraulic flows so that water can be used elsewhere. Thus, limiting the silting up of dams is the result of a policy oriented towards regional hydro-agricultural development. In the same way, upstream groundwater recharge plays a role in using upstream water to supply downstream urban areas with drinking water. In this case, the role of hillside reservoirs is considered at the regional level and no longer at the local level.

These contradictions are embodied in the mode of operation of hillside reservoirs: several different hydrological operating modes are expected of the same type of infrastructure. Reservoirs intended for groundwater recharge, for example, should facilitate infiltration of runoff water, and consequently empty rapidly. Conversely, reservoirs intended for local irrigation should collect as much water as possible and store it for use in periods when crops need water. Reservoirs designed to limit silting up of dams must “trap” as much sediment as possible, consequently they silt up rapidly, thereby reducing their water storage capacity and their lifespan.

Theoretically, the location, design and dimensioning of the technical objects serves to meet these diverse objectives. Despite robust technical expertise (Zucca et al., 2015), the operating process of hillside reservoirs can make it difficult to match their expected functions. The problem of trying to match functions and modes of operation appears to be partly resolved through a shift in the discourse by the administrations in charge of these developments. As we observed in the discourse recorded during several meetings of the regional administrations in charge of water management and agriculture, in Kairouan, the flaunted functions of a reservoir may evolve with its actual operation. For example, the recent argument in favor of groundwater recharge appears to be the result of a change in the discourse concerning reservoirs that have failed to hold water for irrigation. The implementation of a new development program may also alter the role officially attributed to a reservoir. For example, some reservoirs designed to limit silting up of downstream dams but that have satisfactory filling characteristics have been included in the irrigation component of the "Kairouan Hills" rural development program (Cheikh-Rouhou, 2014). This could be one illustration of the pragmatism deployed by the officers in charge of managing the contradictions that underlie public policies. But this does not solve the concrete effects of these contradictions when these reservoirs are constructed on territories that have already been appropriated, organized and valued by their inhabitants.

3. Sociohydrological narratives of four hillside reservoirs

The aim of the next stage in our investigation was to understand how people living in the vicinity of reservoirs dealt with these technical objects and the contradictions they embody.

3.1. A negotiated ethnography of hillside reservoirs

The Merguellil wadi catchment is located in the mountainous hinterland of the Kairouan region in central Tunisia, it is known as a marginalized area and is somewhat neglected by public actions (Attia, 1984; Gana, 2012; Fautras, 2015). Until the middle of the 20th century, the great semi-nomad Jlass tribal confederation used this vast semi-arid area for transhumant livestock breeding and extensive dry cereal farming (Valensi, 1977). Their economic activities were based on the complementary use of local resources and mobility. In the last century, rural and agricultural development policies have encouraged a shift to sedentary and more intensive farming practices. Irrigation started to play a central role in the production systems of the vast plain located downstream. Upstream, water and soil conservation programs sought to reduce soil erosion and soil loss as well as prevent the silting up of the large downstream El Haouareb dam. Most hillside reservoirs were thus not specifically designed to develop local irrigation (Ogilvie et al. 2019). However, hillside reservoirs “create” a potential water supply and populations see their semi-arid territory becoming the site of potential hydro-agricultural development. It is easy to imagine both the expectations that these developments generate, and the stakes they represent locally.

However, despite the abundant literature on hillside reservoirs, very little has been published about how local “beneficiaries” really perceive and welcome the reservoirs. As we have seen, most research focuses on their hydrological functioning, while only a few authors have studied the “uses” and associated economic benefits of the reservoirs (e.g. Selmi, 1996; Selmi and Talineau, 1997; Fleskens et al., 2005). These works conclude (negatively) that reservoirs are “underused” (Selmi, 1996, p. 256), or “manifestly underexploited” (Selmi and Talineau, 1997,

p. 462). However, the reservoirs were evaluated without considering the original function attributed to each reservoir. Can this explain the observed “under-exploitation” of hillside reservoirs?

The decision to survey people living in the vicinity of the reservoirs was made rapidly. However, defining the approach to use (the number of people to interview, the selection criteria) was less straightforward given the hydrologist's quantitative concerns about representativity and extrapolation/regionalization and the anthropologist's qualitative and comprehensive orientations. A sociohydrological negotiation (Massuel et al., 2019) led to a methodological compromise, whereby we conducted an extensive rapid survey of all the reservoirs in the Merguellil catchment (Ogilvie et al., 2019), followed by an in-depth ethnographic study of a limited number of case studies that we selected jointly.

First, we considered it necessary to further investigate the apparent “underuse” of reservoirs, as certain uses do not emerge in disciplinary evaluation frameworks. An inventory of nearly 50 reservoirs was therefore drawn up for the entire catchment that identified a wide variety of situations in terms of technical characteristics and of management and uses of the stored water. This characterization of reservoirs, combining both social and hydrological aspects, led to a novel classification of the diversity of hydro-sociosystems (Ogilvie, 2015; Ogilvie et al., 2019). Four reservoirs chosen to illustrate this diversity were then selected for the qualitative in-depth ethnographic study. Figure 3 provides a visual overview of the reservoirs (see fig. 1. for their location). Their - inherently caricatural - descriptions: “frequently empty”, “dying”, “untapped”, “unreliable” result from our analysis of interviews with people who live in the vicinity of the reservoirs.

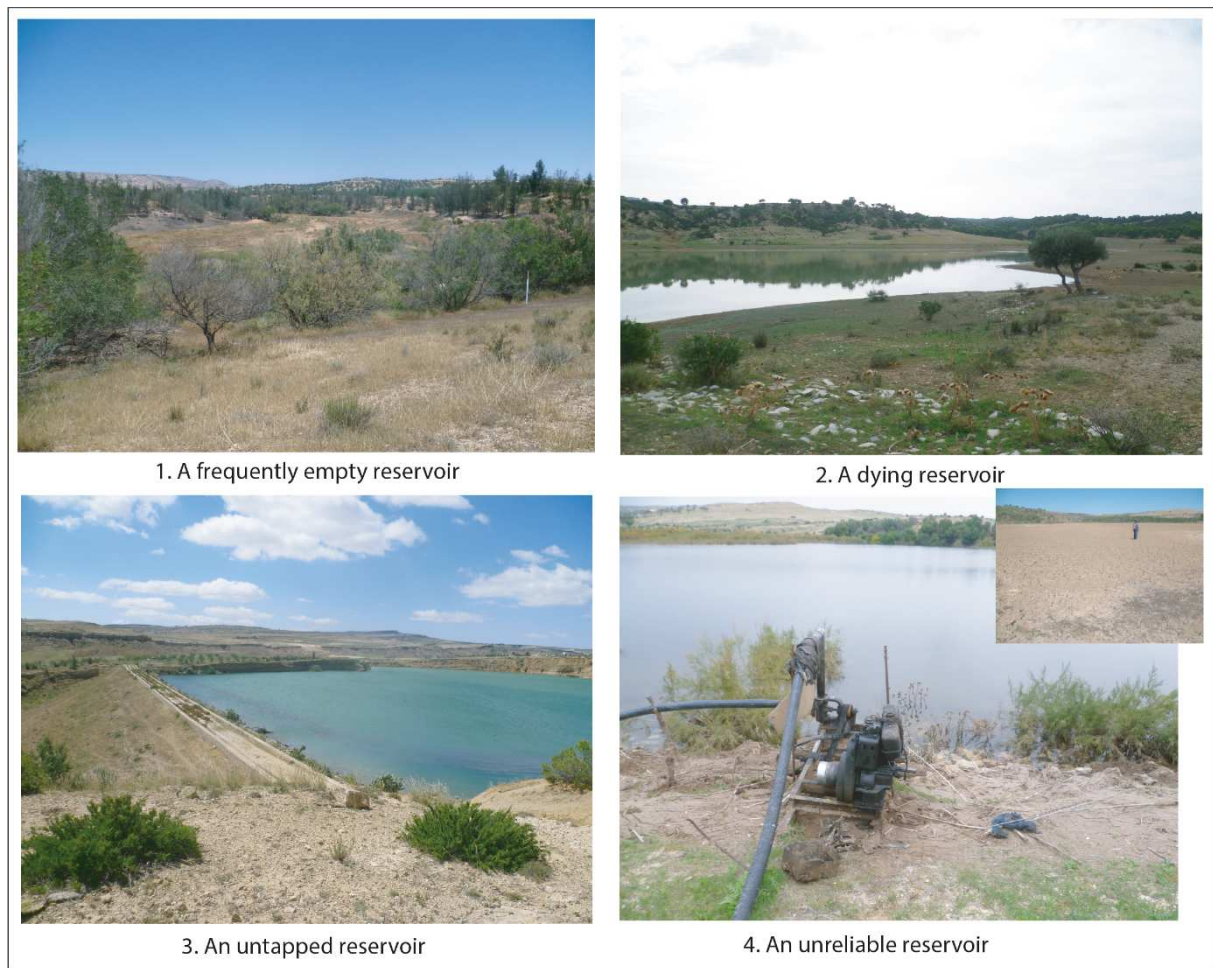


Figure 3. Visual overview of the hillside reservoirs investigated in this study

The ethnographic process combined observations and repeated in-depth interviews with key people influenced by these reservoirs at the local level. The field investigation mainly focused on the social groups in the vicinity of the reservoirs, but complementary interviews were conducted with authorities, project managers and entrepreneurs, and written sources (bibliography and reports) were used to check, or clarify statements and viewpoints. In addition to our interdisciplinary negotiation, two components of the socio-political context constrained our approach: (i) the small number of people concerned by these reservoirs: in most cases only a few households, who often belonged to the same family group (*aârch*), (ii) the political situation where, despite the Tunisian revolution in 2011, the population remains reluctant to talk about former local political networks and their ongoing transformation. Interestingly, the hydrological focus on the technical aspects of reservoir operation offered a novel ethnographic

solution. Apparently neutral questions on the construction, storage capacity, operation and management of the reservoir, provided an entry point to conduct multiple, repeated interviews and to gradually broach more sensitive topics. We first interviewed all the households living near the four reservoirs studied, with emphasis on those whose water was used for crops or livestock. We then conducted in-depth interviews with the “reservoir warden” of each reservoir, designated by the State administration, whose role includes the surveillance and management of the reservoir.

In the second stage, we assembled the ethnographical material we had on each reservoir to trace its history, which resulted in four “sociohydrological narratives”. The notion of “sociohydrological narrative” refers both to the fact that the narratives are a construct of the observers, and to the interdisciplinary process that played a central role in this construction (Riaux, 2019). Our analytical procedure is based on the compilation and interpretation of the individual stories. Each sociohydrological narrative thus tells the story of a social group through its reservoir and with its specificities.

3.2. The story of a frequently empty reservoir

Built between 1989 and 1991, the first reservoir owes its name: *Hoshas* (gravel), to the substrate on which it was built. Our interviewees emphasised this characteristic, and the fact that gravel enables rapid infiltration, thereby preventing the accumulation of water. This problem was mentioned by all the interviewees: this reservoir is usually dry. In 2013, it had not filled up for at least five years, and had consequently provided no water for livestock, irrigation or domestic use.

When they were asked to tell us the story of their reservoir, the local people first explained the history of their settlement. They belong to the Ouled Sendassen, a fraction of the Jlass tribal confederation. In the 1960s, their family received a piece of land from the State in recognition of their involvement in the struggle for independence. The legal status of this land is precarious

and, as the deeds have never been formalized, they provide only land use rights. At that time, families practiced small-scale livestock farming and grew rain-fed crops. According to the interviews, water was scarce and came from an intermittent wadi and a few springs, and was only used for domestic puposes and to water livestock.

In the 1970s, the State encouraged the development of irrigated fruit trees. Government subsidies for digging wells allowed olive and apricot trees to be planted, but the population soon witnessed a significant drop in the water table, thereby restricting their access to water. To explain this drop, one interviewee blamed the increasing withdrawals by the National Water Company (SONEDE) to supply drinking water to the cities located downstream. Pumping has become too expensive, due to the cost of diesel fuel, and many people gave up irrigation. Only two people explained that they have kept their wells and only irrigate olive trees, which are more resistant to drought than apricot trees.

Given this situation, it is easy to imagine how people might have reacted to the idea of having a reservoir in their territory. As one interviewee explained: *“when they built the lake, we thought we would benefit from it”*. Indeed, according to the interviewees, this is what the authorities led them to believe: in exchange for building the dam on their land, people received olive tree saplings. Early on, one person tried to use the water from the reservoir: *“I bought a pump. In the year it was built, the water level rose, so I was able to water my apricot and olive trees”*. However, this activity was short lived: *“now, there is no longer any water. My four sons moved to the urban area of Sousse to work in construction”*.

The literature reveals that this reservoir was originally designed for groundwater recharge (République Tunisienne, 2006), but the inhabitants only learned this after its construction: *“Initially, we were told nothing about groundwater recharge. When we asked if pumps could be installed, the people from the Ministry replied no and explained that the reservoir was there for groundwater recharge”*. The rapid infiltration of water in this reservoir therefore matches

the objective of its construction. Indirectly, the lake helps raise the water table as some farmers in the surrounding wells have observed: *“the wells near the lake have the highest water level. Everything is connected. My neighbor is happy when he sees water in the reservoir, because he knows that the level of water in his well will rise.”*

3.3. The story of a dying reservoir

Built in 1990, the “Gouazine” reservoir was built on six hectares of a 40-ha territory, allegedly granted in 1924 by the State to the ancestors of the current inhabitants. Until now, inherited land rights remain collective. We were told two different stories about the origin of this reservoir. Some interviewees claimed that state officers conducted studies and said they were going to build a dam to prevent soil erosion and to recharge groundwater. Most of the inhabitants then disapproved of the project because they did not want to give up their land. *“In the past, each family raised up to 600 sheep and we employed a shepherd. To us, land was more important than water”*. Our interviewees said that counterpart payments were promised, so they signed, but received nothing in return. *“Finally, the administration (daoula) said it was its land”*. According to other interviewees, the inhabitants themselves requested the construction of a reservoir *“to help provide water for livestock”*. They thought that a reservoir would counteract the declining water level in their wells. They sent a representative to the local agricultural office to offer their land to build the reservoir. A few months later, engineers arrived, a study was conducted, and the State funded the construction.

These two stories provide interesting insights into the satisfaction and dissatisfaction generated by this reservoir. Those in favor of the reservoir pointed to the local advantages it actually provided but they nevertheless all reported previous disappointments with the lake. Two years after its construction, people received pumps and olive tree saplings from State development programs, although the reservoir was intended for another purpose. In addition, the District agricultural advisors reportedly recommended the cultivation of watermelons based on an

analysis of local soil conditions. One inhabitant explained that he bought a pump to grow market garden crops using water from the new reservoir. This succeeded for four years, but then the water level in the lake became too low. A group of ten people used another pump the State had entrusted to a dedicated water user association². The association operated correctly: all the rightholders (about 10 families) took turns, pumping water for three hours, morning and evening, *“no more, because we didn’t want to dry up the reservoir”*. There were no financial contributions to the association, but each user paid for the diesel fuel he used for pumping. After six years, the lack of water in the reservoir led the farmers to stop growing irrigated crops around the reservoir. The pumps were transferred to pre-existing individual wells located downstream of the dam. The interviewees said that the construction of the reservoir had a positive influence on the level of water in the wells, which was confirmed by hydrological observations (Selmi and Nasri, 1997). However, water scarcity now limits income-generating crops, as one well owner explained: *“we can’t rely on the reservoir, and water from the wells isn’t enough for everything”*. He continued: *“Lots of people have left the area because of the lack of water”*. Since then, people have limited their activities to growing rainfed cereals and olive trees. Today, the lake dries up every year. In 2011, it remained dry for eight months. To explain the lack of water, the interviewees pointed to low rainfall over the last three or four years. They also complained about the quality of the infrastructure and leaks: *“the contractor was young and didn’t have any experience. His main concern was making money, and he botched the job”*. However, they generally attribute low water availability to the reservoir silting up: *“with the silt, it’s never full”*. The inhabitants describe the reservoir as “dead” (*imut*). They are now considering two ways to get water: constructing a reservoir downstream or removing the mud from the lake. People expect the State to do something about it, but no plans were

² As part of the initiative to transfer water management from the State to the users (a condition of loans from the donors), associations were created to manage the hydraulic infrastructures (Canesse, 2010). The results of this policy appeared to be particularly poor around the hillside reservoirs (Selmi, 1996).

found. These statements corroborate the literature as the lake was reportedly designed both to support groundwater recharge and to reduce the silting up of the large dam downstream (Selmi and Nasri, 1997). By fulfilling these regional functions, this second hillside reservoir lost its ability to function as a local water resource: it quickly accumulated silt, its storage capacity decreased and it is now often empty.

3.4. The story of an untapped reservoir

Completed in 1992, “El Morra”, is one of the biggest reservoirs in the region. Land around the lake can be divided in two distinct territories: land upstream belongs to a Sendassen lineage, part of the Jlass, and land downstream belongs to a lineage of the Ouled Ayar tribe, once rivals of the Jlass. There are no deeds for the land, and one inhabitant explained that the heirs of each lineage manage the land jointly. Before the reservoir, inhabitants grew rainfed wheat and barley, and each family kept a few cattle and sheep. As the wadi was dry most of the time, no irrigated crops were possible. Another inhabitant explained that the subsoil was not right for digging wells. According to the interviewees and to the literature, in its early design phase, this reservoir, which was funded by the European Union, fulfilled a hydro-agricultural development objective (République Tunisienne, 2006). However, irrigation did not expand as expected, and farming activities around its banks remain scarce, considering the lake has a storage capacity of about 700,000 m³ (Pabiot, 1999). Currently, water from the reservoir is used to water livestock, for domestic purposes and limited amounts for irrigation. The inhabitants' narrative partly explains the repeated failures to exploit the water in the reservoir. From 1994 to 1995, the rural engineering department of Kairouan implemented a vast irrigation project based on the exploitation of the water stored in this reservoir. The technical project included large-scale infrastructure including a basin located downstream of the reservoir dike, and a pumping station to convey the water to a water tower located 2 km upstream of the reservoir intended to supply the future gravity-fed irrigated perimeter (Pabiot, 1999). However, according to interviews with

regional authorities, once the installations were complete, the project had difficulties due to the cost of electrification, and was abandoned.

In 1998, the regional agriculture office installed two pumps so that people could irrigate the crops growing near the reservoir (Pabiot, 1999). To this end, a Water User's Association was created. Initially, around 15 families collectively used the two pumps to irrigate summer crops (watermelons, bell peppers, tomatoes), winter crops (beans, peas) and olive trees. This worked well for two years. However, problems soon arose, as evidenced by the need to hire a warden to oversee the pumps from the second year. Next, one of the pumps broke down, and the other was swept away in a flood. The reservoir warden told us he had retrieved the pump, repaired it and kept it for his own use until now. In the meantime, the warden asked the regional authorities for water to be drawn from the storage basin downstream of the reservoir. His aim was to irrigate his own land downstream of the reservoir dike. The authorities finally approved his application in 2003. This allowed him to cultivate several hectares of fruit trees and vegetables, until now. In addition to this income-generating activity, this inhabitant receives a far from negligible remuneration from the State for his job as a warden.

For those living upstream of the reservoir, irrigation remains very limited: *“once a month they collect water in buckets and containers to water around ten apricot and almond trees per family”*. Several have left the area to look for work elsewhere. According to one interviewee, they cannot afford to invest in agriculture: *“we’re not really farmers here, because we don’t have the means [...] With a good harvest, we can pay for water, electricity, the doctor... but then there is nothing left over”*. Finally, several people explained that the problem lies in the connection between water and cultivable land, which is located at quite a distance from the reservoir. In addition, access to the reservoir is not easy, and irrigation requires technical means that (apart from the warden), the inhabitants do not possess.

3.4. An unreliable reservoir

Built in 1992, “El Guettar” is one of the reservoirs most intensively used for agriculture in the Merguellil catchment. Since the beginning, it has been dedicated to local development (République Tunisienne, 2006). This reservoir is characterized by the regular presence of a relatively large amount of water, which supplies around 15 families. Water from the reservoir is used to water livestock, for irrigation, and to fill mobile cisterns, with a capacity of about 1000 liters, sold for watering trees. However, the situation is far from idyllic: in addition to the significant and unpredictable variations in the quantities available, many conflicts have arisen around this reservoir.

It was built on a space, which, for several generations, had been occupied by families from the same lineage. Several interviewees connected this lineage to the famous Ouslet tribe, former inhabitants of the region, which was supposedly expropriated and dismantled to benefit the Qaoub tribe (part of the Jlass) in the 18th century (Gammar, 1999). In the past, the land on which the reservoir is located was divided into two parts separated by a wadi. One ancestor’s descendants lived on the right bank, while the left bank belonged to the descendants of this ancestor’s brother. The first group held power in the region, while the second group depended on the first: *“his grandfather worked on other peoples’ land, he had little land of his own”*. Today, the balance of power between these two lines has been reversed. Although the descendants of the most powerful family still enjoy a certain respect, the once underprivileged family now occupies a prime position, both economically and politically. As it happens, the head of this family is the reservoir warden.

Our interviewees again emphasized the problem of land tenure. They explained their land was part of a vast area of agrarian colonization, brought into the State domain at the time of Independence. Inhabitants paid to obtain a property deed (*hojja*). But in the meantime, this kind of deed has been replaced by modern individual “blue deeds”. The lack of updated “blue deeds” creates distortions over the ownership of the land on which the lake was built, and several

people claim to own it. Once again, there are several versions of the story of the reservoir's construction. Some say the initiative came from the Ministry of Agriculture: "*after Independence, the engineers from the Ministry of Agriculture wanted to build reservoirs. Tunisian and French engineers arrived. They wanted to block off the water from the wadi, so that everybody could benefit*". "*The farmers signed a document agreeing to give their land, because they were interested in the water*". Others claim the initiative came from the community. "*It was the inhabitants who applied to the State. After that, the engineers came and did a study. Then they built the dam*". However, one fact on which everyone agrees is that the reservoir was designed to store water for local use.

Even then, interviewees insisted that irrigation began before the reservoir was built. Before Independence, this huge space was used for large-scale livestock farming, which required mobility and inter-tribal agreements, characteristic of the tribal life in Central Tunisia (Valensi, 1977). After Independence, several rural development programs were launched "*by Bourguiba*", the first president of Independent Tunisia. Public subsidies allowed people to start growing fruit trees, and hence to progressively abandon livestock farming. The few existing water sources were modestly exploited: "*water was already here before, it came from the wadi, which they used for irrigation. They used buckets to water a few trees*". In the 1980s, there was a boom in irrigated arboriculture (olive and almond trees), again encouraged by State aid: "*you just had to dig the holes, and you were given the same number of olive trees*". Wells were dug and the first pumps were introduced: "*to start with, we received credit to buy a pump for a well*". Arboriculture and irrigation therefore developed before the creation of the lake, as summed up by one of the inhabitants: "*the transition happened before the lake*".

The reservoir offered the possibility to develop irrigated crops, but only to a limited extent due to the major uncertainties about its filling. Most of the interviewees emphasised the role of the reservoir in protecting the olive trees during dry periods. When there is not enough water in the

reservoir, the olive crop comes first. To save their trees, people are sometimes obliged to buy water from mobile tanks filled elsewhere. Most plots are used for rain-fed farming. Next come winter crops (beans, peas, carrots), cereals (barley, wheat) and, only for families with reliable access to water, summer crops (squash, chillies, zucchini). These crops are grown for the inhabitants' own consumption, but some people manage to grow enough to sell on the local market.

Various hydro-agricultural practices can be identified, depending on several factors. On an annual level, crops are chosen by evaluating the amount of water available in the reservoir. Despite the forecasts, major crop losses often occur. For example, following a rainy year, one of our interviewees planted vegetables in a one-hectare plot, but spring was drier than expected and he lost everything. Another explained that following two years of poor harvests, he could no longer afford to invest in his land. He therefore focused on saving his olive trees while working as a laborer in town to feed his family. Agricultural practices and their benefits vary depending on the location of the plot, access to a functioning pump, or access to other sources of water (well, spring or wadi). Most people are only able to look after their olive trees, by watering them two to three times a year. The reservoir warden is in a more advantageous position: he has permanent access to the reservoir, owns a functioning pump and a plot situated directly downstream of the reservoir. His olive harvest is good, and he grows market garden crops in winter and sometimes in summer. Even better placed are families who live downstream of the reservoir, close to a spring. They use water from the reservoir, as well as from the spring. These families have substantial orchards, each of around four hectares. They can grow both summer and winter crops every year. Finally, a man allegedly an investor from Kairouan purchased land in the area. He has planted over five hundred olive trees he irrigates with a well located in the reservoir itself. He has plans for a borehole and to extend his farming business.

The interviews point to the increase in market gardening as an explanation for the decreasing quantities of water available in the reservoir. There is no collective organization, no rules that limits the cultivated areas or the amounts of water taken. The regulating factor for withdrawals is purely technical: either you have a working pump or you do not, either your pipes are long enough, or they are not. This is an important point, since we were given a lot of information about how public aid (donations of pumps and pipes), on which these technical possibilities depend, is hijacked to benefit those who have close relationships with local key figures and with the authorities, especially the reservoir warden.

However, generally speaking, the inhabitants are satisfied with the lake: *“The lake is well constructed, so it collects a lot of water”*. They nevertheless point to the role of rainfall and the variability of this resource: *“One night’s heavy rainfall can fill up the lake”*. The problem is that this means access to water is completely dependent on rainfall amounts, which are highly variable here: *“There’s water, but there’s always a risk”*. Periods with no water can last several months, threatening farmers’ plans. On the whole, access to water is considered to be too unreliable. The people want the State to intervene to secure access by drilling a borehole.

4. Hillside reservoirs’ materiality and the process of resource making

The sociohydrological narratives articulate four main moments in the local history: the context when the reservoirs “arrived”, attempts to exploit reservoir water, difficulties encountered, and finally concerns about the future of the reservoir. These narratives clearly present reservoirs as resources, more precisely as technical means involved in the process of making water a resource for agricultural development and thus, as a result or an ellipsis, the reservoir is presented as a resource. However, this resource is described as “unreliable”, “insufficient”, “unsatisfactory”, and so on. Hydrological analyses confirmed the highly variable nature of the filling and emptying of the reservoirs (Ogilvie, 2015; Ogilvie et al., 2019). So, how can we explain that all

our interviewees, without exception, approved the presence of their reservoir and were worried about its future? Why would they want to preserve such an unsatisfactory resource?

This apparent paradox fuelled the sociohydrological negotiation between the authors. We first considered that this contradiction might be the result of a bias in the enquiry, as the interviewees often asked us to relay their claims to the authorities, to report technical damage or difficult living conditions. It therefore seems logical that they would both mention problems and express positive opinions about their reservoirs. However, another interpretation is also possible. Inspired by the literature on natural resource making (Mosse, 1997; Baviskar, 2003; Bos and Grieco, 2018), we hypothesized that reservoirs represent resources that go beyond their hydraulic and productive functions. In order to deepen the analysis, we needed to abandon the classical view of “water resources” held by hydrological sciences and where water “is” a resource apart from human action (Baviskar, 2003). This shift allows us to identify the different ways reservoirs are turned into a resource by the different actors involved.

As in our case, the process of resource making is mediated by a technical object: a reservoir, we considered it would be enriching to apply a sociotechnical reading of this process. More specifically, we chose to rely on the analytical proposals of Sigaut (2010), who showed that the functions an object assumes can only be identified by observing it when it is operating. For example, the function of a knife is not to “cut”. “When cutting”, a knife can indeed fulfil a variety of functions, including slicing, sawing, scraping, and carving. This explains the variety of shapes a knife can have (Sigaut, 1991). We therefore changed our original research question from how do people use the water from the reservoirs, to: which reservoir operations do the actors capture in a process of resource making? We identified two main aspects. First, the hydraulic action of reservoirs on hydrological processes, and second, the role played by the materiality of reservoirs in social relations.

4.1. The hydraulic action of reservoirs in the making of water resource

We first considered the hydraulic action of the hillside reservoirs on a physical space. From that point of view, a hillside reservoir is the result of a combination of physical elements: topography, soil, surface water and groundwater, and an assemblage of technical objects: dike, spillway, de-silting gates, etc. This combination takes the form of a "lake" which, depending on both physical processes (runoff, infiltration, flooding, drought, etc.) and human actions (opening/closing of gates, maintenance of structures, withdrawals, etc.), may be full of water or empty. What we called 'hydraulic action' is the capacity of the reservoir to act on hydrological processes. This action can follow three different paths: stopping a hydrological flow, thus creating water storage; modifying surface/ground relations by favoring the infiltration of surface water, thus recharging groundwater; stopping the flow of sediments by trapping them in the lake, thus favoring water storage in other places (in addition to preserving downstream land/soil integrity). Depending on its main action, a reservoir stores water or does not. Depending on how it operates, it cannot perform the same functions in the process of resource making. The people who evolve around one of these reservoirs will then take advantage of its hydraulic characteristics and transform it into resources according to their own needs and opportunities.

We have already mentioned that the administrations in charge of water and/or rural development mobilized the multiple hydraulic actions of the reservoirs, depending on the successive policies underlying the planning process. Thus, thanks to a certain pragmatism, the reservoirs can fulfil various functions, each corresponding to a different way of looking at water development. Reservoirs thus respond to different visions of making water a resource that can be seen in turn as local or regional, centred on surface water or groundwater, based on a centralised vision of water management or responding to a local vision of development. But, at the planning level, what is important is the addition of the actions of several reservoirs on a river basin, or the complementary actions of several hydraulic works (reservoirs plus

downstream large dam; reservoirs plus water catchment). In the framework of water policies, the action of a single reservoir does not make much sense. For example, the policy of protecting large dams from silting relies on the cumulative action of numerous reservoirs over the whole catchment, i.e. the objective of 1000 reservoirs planned in the Water and Soil Conservation Program. Depending on the policy underlying their action, the administrations involved can then choose which reservoirs to refer to, depending on the hydraulic action they undertake, so that they then correspond to the targeted effect.

People living next to a reservoir can only refer to one reservoir that offers itself as a potential water resource. The inhabitants then learned to deal with the hydraulic action of the reservoir built in their territory. This explains the in-depth knowledge many of our interviewees have about their reservoir, whether it concerns its filling, emptying, clogging, and its communication with groundwater, etc. In all cases, the inhabitants have developed a close relationship with these objects by trying to make the most of the reservoir in order to improve their livelihoods, and to make water an economic resource. When full of water, reservoirs fulfil different functions, supplying both livestock and crops, and meeting various domestic needs. Reservoirs allow water to be used directly (pumped from the lake) and indirectly, by replenishing water tables and wells, or filling mobile tanks. However, in the Merguellil catchment, the advantages of the presence of these reservoirs appear to be low compared to those in other situations, where valuable activities such as flood recession agriculture or fish farming are implemented³. This “under-valuation” is due to the limited, intermittent and unreliable nature of the hydraulic resource. As our interviewees explained, in most cases, limitations have arisen, whether physical (e.g. nature of the soil, the reservoir's emptying characteristics or technical problems with the work) or socio-political (e.g. a ban on using water from the reservoir, lack of technical means to transport the water to their plots, failure of collective action). Only a few people

³ See examples in the special issue of *Water Alternatives* edited by Venot and Krishnan (2011).

manage to get around these problems, either thanks to the position they occupy on the territory: i.e. their plots of land are located downstream of the reservoir, access to an additional water source, or by the social position they occupy which allows them to overcome physical constraints, in particular by obtaining public aid or having financial assets to secure additional pumps or water sources. However, this category of “beneficiaries” remains in the minority. For most people, the use of water from the reservoirs is limited to watering their trees in the driest periods. Yet it is worth noting that this supplement, however small, is important. Although it is not a significant “economic resource”, it plays a key role for the families, by keeping plantations alive and by making it possible to remain in the area. Although it is not a significant “water resource” it is an important “social resource”. This explain the concern of inhabitants about the future of the reservoirs, especially since nobody can tell them exactly how long they have before their reservoir “dies”.

Therefore, in addition to the contradictions that exist concerning their functions, the hillside reservoirs are considered in a very different way by the administration and by the local inhabitants. Where an administration sees a component in the implementation of a regional policy, the inhabitants see a potential resource that they often fail to value due to lack of support. However, inhabitants underlined the fact that the obstacles to exploiting reservoir water are not only political, but above all physical. Likewise, the finding of "under-valuation" of Tunisian hillside reservoirs is explained. As emphasised by Bakker and Bridge (2006: 10), the social approach of resource making must not disregard the contingency of biophysical processes, as *“the processes and capacities that constitute 'nature' frequently resist or confound its production in ways that enable accumulation”*. Here, reservoirs are often unable to play an effective role in the local accumulation of water, and thus, prevent the local process of water resource making, either because their real function is to relocate this process elsewhere, or

because nature resists, i.e., the local hydrology and/or topography does not allow the hydraulic action of the reservoir to be fulfilled.

4.2. Hillside reservoirs' materiality and the process of symbolic resource making

The second way of looking at the functions performed by hillside reservoirs in the process of resource making also focuses on their physical properties. But this time, it refers to their “materiality” as hydraulic objects, visibly anchored in the physical and social space (Aubriot, 2013). Indeed, the different actors present seize, each in their own way, the materiality of the reservoirs and give it different roles in their world of meaning.

Through the sociohydrological narratives, our interviewees told the story of both the construction of a reservoir and that of a "new" social group. The members of this group are linked by belonging to the reservoirs' territory and as (potential) "beneficiaries" of the stored water. The accounts of the construction of these reservoirs then represent a kind of ontological narrative, which recounts the foundation of the group and legitimizes its organization. From then on, the reservoir is part of the “production of locality”, to take up the analysis of Appadurai (1997) that Mosse (1997, p. 498) transposes to the Indian water tanks: *“They are part of the socialization of space and the 'production of locality', both in itself and in opposition to other localities as social and ecological places”*. The production of the locality around hydraulic objects is, in the Tunisian case, externally driven and very recent. In this case, the “hydraulic locality” is built on land whose appropriation and use was previously organized around lineage and extensive livestock breeding. The insistence of our interviewees on the changes in productive activities towards sedentary arboriculture reveals the depth of the changes operated by the inhabitants in recent decades and in some way ratified by the ‘arrival’ of a reservoir. The place of the land property issue in the narratives reveals the importance of reaffirming the limits and the hierarchical pre-existing organization, despite the socio-spatial reconfigurations occurring around the reservoir. It can also be seen as a critique of the place that wardens occupy in the

social order of the new “hydraulic locality”. We indeed observed that the reservoir wardens often have priority when it comes to accessing the reservoir, particularly by appropriating the pumps allocated to the water users associations. When the interviews probed deeper into the issue, they quickly turned into a narrative of grievance about wardens’ behavior, whether questioning their legitimacy (because they come from outside the local community, because their families did not originally own any land around the lake, etc.) or criticizing their behavior (abuse of power, abuse of collective property). The reservoir also gave rise to discourse on inequalities and local hierarchies: in other words, a political discourse. The more in-depth the interviews became, the stronger the criticism of the past political regime and hierarchies of local influence.

Another dimension of the accounts concerns the connection that the reservoir creates between the local group and the outside. Populations of the Merguellil area, and more generally the inhabitants of the country’s rural areas, share a feeling of exclusion compared to the economically and politically more favoured urban and coastal areas⁴. Yet, receiving a hillside reservoir on one’s territory involves regular visits from State officers, who assess the state of the hydraulic infrastructures. The presence of these reservoirs also attracts researchers, as is the case of one of the reservoirs studied here, which welcomes generations of research programs. Our presence was part of this. Consequently, these reservoirs create or maintain a dialog with the outside. The reservoir then presents itself as a “relational resource”. But the relation is created, directed and maintained by the State in an almost unilateral way. Moreover, the State's interest in “the reservoirs” as a whole and not in “this particular reservoir” clearly unbalances the relationship: the interests of the members of the hydraulic locality do not necessarily match those of the authorities. Moreover, the appropriation of the reservoir by the inhabitants is not

⁴By studying the case of Sidi Bouzid, also located in central Tunisia, Fautras (2015) explains the role that this feeling of exclusion played in the social process that led to the Revolution in 2011. See also Ayeb (2011), Gana (2012).

necessarily desired. To cite one of the inhabitants: “*water belongs to God, the dam belongs to the State*”; the hydraulic administration keeps its responsibility for the reservoirs and delegates their supervision to wardens who are chosen and remunerated by the administration itself. This partly explains the weakness of the collective initiatives in the hydraulic localities.

The relationship between the State and the local communities is characterized by a misunderstanding fuelled by discrepancies between the planning objectives and the way in which the projects were implemented. When the inhabitants saw technical teams arriving with materials and machines, they probably expected greater changes, creating disproportionate hopes. The provision of saplings, pumps and agronomic advice reinforced this hope. The creation of water user associations probably also reinforced the trend: the “beneficiaries” believed they were being offered a project for agricultural development, as can be seen in the nearby Kairouan Plain. They therefore did their utmost to make the most of this “new” water, showing great inventiveness and a high propensity for risk-taking. The failures inevitably led to disappointment. In trying to reconcile “Water and Soil Conservation” and “Integrated Rural Development” policies, the different services involved left room for misinterpretation. The different actors filled this space according to their own specific objectives and possibilities. While the role of the Water and Soil Conservation services was to construct reservoirs, the agricultural development officers saw an opportunity to develop irrigation. The international donors also seized the opportunity, offering funding to develop irrigation and hence honouring some of their commitments to the country. The population probably staked too much on this undefined space in the projects, with expectations the reservoirs were not always designed to meet. Consequently, even if the reservoirs fulfil what may be their original planned functions (e.g. groundwater recharge or sediment capture), they do not live up to the hopes of the populations.

The sociohydrological narratives also emphasized this unbalanced relationship with the State. Referring to their “gift” of land to build the reservoirs, the inhabitants insist that the State has failed to “give back”. The State is therefore considered indebted to the group, which explains the repeated requests for public aid to produce or secure local water resources.

The material existence of the reservoir thus feeds the making of relational resources. Once again, the reservoir warden is first in line. The spatial and social position of the warden with respect to the reservoir gives him the opportunity to assume a role as an intermediary between the hydraulic locality and the authorities, a role that can be interpreted as that of a development broker (Biershenk et al., 2002). The warden is then viewed as the mediator of a multidirectional relationships materialized by the reservoir. On the one hand, he conveys the collective discourse on the reservoir to outside visitors, insisting on its failures and on the debt the State has towards the hydraulic locality. He then participates in the production of this locality, production of which is part of its own relational resource. On the other hand, the warden strengthens the public authority over the reservoir and over the locality. He thus participates in the State’s process of political resources making. Thus, the warden is both the main beneficiary and the main producer of the resources making process around the reservoir. To produce its own resources, the warden relies on the different logics involved, playing on contradictions thereby reinforcing misunderstandings.

5. Conclusions

Tunisian hillside reservoirs are embedded in a multiform process of resource making, where the created resources are both productive and symbolic. Each actor appropriates this technical object and makes it embody their own objectives, play different roles, in turn contradictory and complementary.

Hillside reservoirs therefore not only fulfil a productive function by supplying water for several uses. They also generate relational resources. On the one hand, the reservoirs are at the heart of

the production of a "hydraulic locality" around which rural populations are recomposing a socio-political order in a deeply modified productive landscape. On the other hand, they materialize the authority of the State even to the ends of the nation. As a result, the limits that certain reservoirs present in terms of local productive resources are used to produce relational resources. In this process, the reservoir warden plays a central role as a "resource broker", by mediating the relationships between the locality and the public authority, between the reservoir and the resource making processes used by the different stakeholders.

This analysis emphasizes the value of moving beyond the essentialization of water as a resource to go further in the social and political process underlying the production of the various resources that can be produced from a reservoir: local or regional water resources as much as social and political resources. This also reveals the different logics at work around the reservoirs and the way these logics interfere with each other, sometimes leading to contradictions and misunderstandings. However, it is also essential to account for the strong influence of biophysical processes on the social and political dynamics involved in the resource making process. Biophysical contingencies constrain water resource making, thus revealing other kind of resources that hydraulic objects could provide.

The analytical entry associating the technical object, its materiality and its action on biophysical processes is particularly enlightening for the analysis of resource making processes. It allows the observation that, in the case of Tunisian hillside reservoirs, the shape and operating of the technical object are not determined, upstream, by the functions attributed to the reservoirs. Quite the reverse, it is because their most obvious and productive functions (storing water) are failing that the actors seize on other possible functions of the reservoir to try to turn them into resources. This transposition work is carried out with equal efficiency by the officers of the State and by the members of the hydraulic locality, particularly the reservoir warden. But the

resulting resources remain unequally distributed among the different actors, forcing the less advantaged to leave the locality.

This last observation links physical, political and social processes, thereby responding to one of the challenges of sociohydrological approaches (Wesselink et al., 2016; Massuel et al., 2018). Consequently, this sociohydrological research on Tunisian hillside reservoirs allows us to affirm that the interdisciplinary negotiated approach, associating observation of technical objects and analysis of the process of resource making, is a powerful way to go beyond the scissions between physical and social sciences, to reconcile the different approaches to water-society relationships.

Acknowledgements

This research was funded by the SICMED programme (MISTRAL) and by the French Research Institute for Sustainable Development (IRD). We are grateful to the interviewees for the time they gave us during the study, especially those living in the Merguellil area and the administration officers from the *Direction Générale de l'Aménagement et de la Conservation des Terres Agricoles* (DG ACTA) and *Direction Générale des Ressources en Eau* (DGRE) in Tunis and local representatives at the Kairouan and Siliana CRDA. We are also grateful to A. Wesselink and F. Molle for their comments on an early version of this text, and the two anonymous reviewers, who helped us considerably improve our analysis of field material.

References

- Appadurai, A., 1997. *Modernity at Large: Cultural Dimensions of Globalization*. Oxford University Press, Delhi.
- Ashraf, M., Kahlown, M.A. and Ashfaq A., 2007. Impact of small dams on agriculture and groundwater development: A case study from Pakistan. *Agric. Water Management* 92, 1-2, pp. 90-98. <https://doi.org/10.1016/j.agwat.2007.05.007>

Attia, H., 1984. Réflexions à propos du développement régional de la Tunisie intérieure et méridionale. In: Blanc-Pamard, C., Editor, 1984. *Le développement rural en question. Paysages, espaces ruraux, systèmes agraires : Maghreb-Afrique noire-Mélanésie*, ORSTOM, Paris, pp. 205-223.

Aubriot, O., 2013. De la matérialité de l'irrigation. Réflexions sur l'approche de recherche utilisée. *J. des Anthropologues* 132-133, pp. 123-144.

Aubriot, O. and Prabhakar, P.I., 2011. Water institutions and the 'revival' of tanks in South India: What is at stake locally? *Water Alternatives* 4(3), pp. 325-346.

Baccari, N., Boussema, M.R., Lamachère, J.M. and Nasri, S., 2008. Efficiency of contour benches, filling-in and silting-up of a hillside reservoir in a semi-arid climate in Tunisia. *C. R. Geoscience* 340 (1), pp. 38-48. [Doi : 10.1016/j.crte.2007.09.020](https://doi.org/10.1016/j.crte.2007.09.020)

Bakker, K. and Bridge, G., 2006. Material worlds? Resource geographies and the 'matter of nature'. *Prog. in Hum. Geogr.* 30(1), pp. 5-27. <https://doi.org/10.1191/0309132506ph588oa>

Baviskar, A., 2003. For a Cultural Politics of Natural Resources. *Economic and Political Wkly.* 38(48), pp. 5051-5055.

Bennet, H., 1939. *Elements of soil conservation*. Mc Graw-Hill, New York.

Berndtsson, R., Jebari, S., Hashemi, H. and Wessels, J., 2016. Traditional irrigation techniques in MENA with focus on Tunisia. *Hydrological Sciences J.* 61(7), pp. 1346-1357. DOI: [10.1080/02626667.2016.1165349](https://doi.org/10.1080/02626667.2016.1165349)

Bierschenk, T., Chauveau, J.P. and Olivier De Sardan, J.P., 2002. Local development brokers in Africa. The rise of a new social category (Working Papers No. 13). Mainz: IFAS.

Bos, V. and Grieco, K., 2018. L'eau : ressource naturelle, ressource politique ? Reconstruction de la ressource hydrique en contexte d'opposition au secteur minier dans le nord du Pérou. *Caravelle* 111, pp. 59-78.

Canesse, A.A., 2010. Rural "participation" and its framework in Tunisia. J. of Economic and Soc. Res. 12(1), pp. 63-88.

Casciarri, B. and Van Aken, M., (Eds). 2013. Anthropology and water(s): Global affairs, local waters and flow of cultures. J. des Anthropologues 132-133.

Cecchi, P., (Ed), 2007. L'eau en partage. Les petits barrages de Côte d'Ivoire. IRD Editions, Paris.

Cheikh Rouhou, M., 2014. Analyse du changement des programmes d'action publique mis en oeuvre sur le bassin amont du Merguellil - Kairouan (Tunisie Centrale). Master Degree, Montpellier Supagro. Montpellier.

Côte, M., 1964. La conservation des eaux et des sols en Tunisie. Méditerranée 2(3), pp. 219-242.

El Amami, S., 1977. Traditional technologies and development of the African environments: utilisation of runoff waters; the meskats and other techniques of Tunisia. African Environ. 3, pp. 107-120.

Fautras, M., 2015. Land injustices, contestations and community protest in the rural areas of Sidi Bouzid (Tunisia): the roots of the "revolution"? Spatial Justice 7, <http://www.jssj.org>.

Fleskens, L., Stroosnijder, L., Ouessar, M. and De Graaf, J., 2005. Evaluation of the onsite impact of water harvesting in southern Tunisia. J. of Arid Environ. 62(4), pp. 613-630. <https://doi.org/10.1016/j.jaridenv.2005.01.013>

de Fraiture, C., Kouali G. N., Sally, H. and Kabre, P., 2014. Pirates or pioneers? Unplanned irrigation around small reservoirs in Burkina Faso. Agric. Water Management 131, pp. 212-220. <https://doi.org/10.1016/j.agwat.2013.07.001>.

Gammar, A.M., 1999. La dorsale tunisienne, entre représentation linéaire et réalité régionale. In: Salem, A. and Naceur Omrane, M., *La Tunisie du Nord : espace de relations*. Publications de la Faculté des lettres de la Manouba, Tunis, pp. 61-83.

Gana, A., 2012. The Rural and Agricultural Roots of the Tunisian Revolution: When Food Security Matters. *Int. J. of Sociology of Agric. and Food* 19(2), pp. 201-213.

Hill, J. and Woodland, W., 2003. Contrasting water management techniques in Tunisia: towards sustainable agricultural use. *The Geographical J.* 169(4), pp. 342-357.
www.jstor.org/stable/3451573

Lacombe, G., 2007. *Évolution et usages de la ressource en eau dans un bassin versant aménagé semi-aride. Le cas du Merguellil en Tunisie Centrale*. PhD Thesis, University of Montpellier, Montpellier. <https://www.documentation.ird.fr/hor/fdi:010043055>

Linton, J. and Budds, J., 2014. The hydrosocial cycle: Defining and mobilizing a relational-dialectical approach to water. *Geoforum* 57, pp. 170-180.
<https://doi.org/10.1016/j.geoforum.2013.10.008>

Massuel, S., Riaux, J., Molle, F., Kuper, M., Ogilvie, A., Collard, AL., Leduc, C. and Barreteau, O., 2018. Inspiring a Broader Socio-Hydrological Negotiation Approach With Interdisciplinary Field-Based Experience. *Water Resour. Res.* (54), pp. 2510-2522.
<https://doi.org/10.1002/2017WR021691>

Mosse, D., 1997. The Symbolic Making of a Common Property Resource: History, Ecology and Locality in a Tank-irrigated Landscape in South India. *Development and Change* 28, pp. 467-504. <https://doi.org/10.1111/1467-7660.00051>

Mugabe, F.T., Hodnett, M.G. and Senzanje, A., 2003. Opportunities for increasing productive water use from dam water: a case study from semi-arid Zimbabwe, *Agric. Water Management* 62, pp. 149-163. [https://doi.org/10.1016/S0378-3774\(03\)00077-5](https://doi.org/10.1016/S0378-3774(03)00077-5)

Ogilvie, A., 2015. *Upscaling water availability and water use assessment in hydro-social systems: the small reservoirs of the Merguellil catchment (central Tunisia)*. PhD Thesis, University of Montpellier/Kings College, Montpellier/London.

- Ogilvie, A., Riaux, J., Massuel, S., Mulligan, M., Belaud, G., Le Goulven, P. and Calvez, R., 2019. Socio-hydrological drivers of agricultural water use in small reservoirs. *Agric. Water Management* 218, pp. 17-29. <https://doi.org/10.1016/j.agwat.2019.03.001>
- Ouessar, M., Sghaier, M., Mahdhi, N., Abdelli, F., De Graaf, J., Chaieb, H., Yahyaoui, H. and Gabriels, D., 2004. An integrated approach for impact assessment of water harvesting techniques in dry areas: The case of Oued Oum Zessar watershed (Tunisia). *J. of Environmental Monitoring and Assess.* 99(1-3), pp. 127-140. <https://doi.org/10.1007/s10661-004-4013-7>
- Pabiot, F., 1999. Optimisation de la gestion d'un barrage collinaire en zone semi-aride. ENSAM, Montpellier.
- République Tunisienne, Ministère de l'Agriculture et des Ressources Hydrauliques., 2006. *Étude d'impact des travaux de CES dans le Gouvernorat de Kairouan, phase 2. Rapport définitif*. CNEA, Tunis.
- Riaux, J. and S., Massuel, 2014. Building a sociohydrological perspective (2). Sharing fieldwork to develop scientific convergences. *Nat. Science Sociétés* 22(4), pp. 329-339. <https://doi.org/10.1051/nss/2014046>
- Riaux, J., Ogilvie, A., Jenhaoui, Z. and Calvez, R., 2015. Les retenues collinaires de Tunisie Centrale : fonctionnement, gestion, usages. Synthèse des recherches et recommandations. AFD, DG-ACTA, IRD, Tunis.
- Riaux, J., 2019. Une anthropologie « chez les hydrologues ». Penser la production de savoirs hydrologiques à travers la relation interdisciplinaire. Thèse d'Habilitation à Diriger des Recherches. Aix-Marseille University, Marseille.
- Roose, E., 2002. Analyse du système des banquettes mécaniques. Proposition d'amélioration, de valorisation et d'évolutions pour les gouvernorats de Kairouan, Siliana et Zaghuan, Tunisie. DG-ACTA/FAO, Montpellier.

Roose, E., Sabir, M. and Laouina, A., 2010. *Gestion durable des eaux et des sols au Maroc : valorisation des techniques traditionnelles méditerranéennes*. IRD Editions, Paris.

Sally, H., Lévite, H. and Cour, J., 2011. Local water management of small reservoirs: Lessons from two case studies in Burkina Faso. *Water Alternatives* 4(3), pp. 365-382.

Selmi, S., 1996. *Interventions de l'État en milieu rural et réactions des collectivités locales face à la gestion d'une ressource rare. Les lacs collinaires dans le semi-aride tunisien*. PhD Thesis, ENSA Montpellier/IRD, Montpellier/Tunis.

Selmi, S. and Nasri, S., 1997. *Les lacs et retenues collinaires en Tunisie*. Rapport Hydromed, ORSTOM/INGRE, Tunis.

Selmi, S. and Talineau, J.C., 1997. Diversité et problématique de la gestion collective des lacs collinaires tunisiens. La ruralité dans les pays du Sud à la fin du vingtième siècle. In: Gastellu, J.M., editor, *La ruralité dans les pays du Sud à la fin du vingtième siècle*. ORSTOM, Paris, pp. 455-470.

Sigaut, F., 1991. Un couteau ne sert pas à couper, mais en coupant. Structure, fonctionnement et fonction dans l'analyse des objets. In: 25 ans d'études technologiques en préhistoire, XI^è Rencontres Internationales d'Archéologie et d'Histoire d'Antibe, Juan-les-pins. Éditions APDCA, pp. 21-34. <http://www.francois-sigaut.com/index.php/publications-diverses/publications/12-articles-fond/220-1991d>

Sigaut, F., 2010. Ideas for observing. *Techniques & Culture* 54-55 (1), pp. 89-97. <https://doi.org/10.4000/tc.4991>

Sivapalan, M., Savenije, H.H. and Blöschl, G., 2012. Socio-hydrology: A new science of people and water. *Hydrological Processes* 26(8), pp. 1270-1276. <https://doi.org/10.1002/hyp.8426>.

Star, S.L. and Griesemer, J.R., 1989. Institutional Ecology, "Translations" and Boundary Objects : Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science* 19(3), pp. 387-420. <http://www.jstor.org/stable/285080>

- Valadaud, R. and Aubriot, O., 2019. Dialectiques hydrosociales à l'épreuve. Décrypter la dimension politique d'objets techniques utilisés pour l'irrigation au Népal. *Développement durable et territoires* 10(3), pp. 1-20. <https://doi.org/10.4000/developpementdurable.15372>
- Valensi, L., 1977. Fellahs tunisiens. L'économie rurale et la vie des campagnes aux 18e et 19e siècles. Mouton, Paris. <https://gallica.bnf.fr/ark:/12148/bpt6k3347904b.image>
- Venot, J.P., Andreini, M. and Pinkstaff, C.B., 2011. Planning and Corrupting Water Resources Development: The Case of Small Reservoirs in Ghana. *Water Alternatives* 4(3), pp. 399-423.
- Venot, J.P. and Krishnan, J., 2011. Discursive framing: Debates over small reservoirs in the rural South. *Water Alternatives* 4(3), pp. 316-324.
- Venot, J.-P. and Hirvonen, M., 2013. Enduring Controversy: Small Reservoirs in Sub-Saharan Africa. *Society and Nat. Resour.* 26(8): 883-897. <https://doi.org/10.1080/08941920.2012.723306>
- Wesselink, A., Kooy, M. and Warner, J., 2016. Socio-hydrology and hydrosocial analysis: towards dialogues across disciplines. *WIREs Water*. [DOI:10.1002/wat2.1196](https://doi.org/10.1002/wat2.1196).
- Zucca, C., Hermassi, T., Ouessar, M., Frija, A., Dhehibi, B., Sghaier, M., Abdeladhim, M., Ben Zaied, M., Haddad, M., Aw-Hassan, A. and Zucca, C., 2015. Impacts of soil and water conservation techniques in Tunisia. Inventory of research works and studies, CGIAR, Research program on Dryland Systems. <https://mel.cgiar.org/reporting/download/hash/KLL9VHDD>.