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Losing Faith: An Exploration of Village Ponds in the Thar Desert

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Dedicated to the GRAVIS family for their hospitality and continued support.

To *laal topi*, may your heart remain kind and your mind unpolluted.

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Glossary of Non-English Terms and Acronyms

***Naadi*:** Village ponds fed by rainwater and used for drinking water collection.

***Oran*:** Community-owned grazing lands dedicated to a deity.

***Gochar*:** Community-owned grazing lands endowed to the public following the dissolution of princely states.

***Panchayat*:** Decentralized village level system of governance

***Diwali*:** Festival of lights in month of October or November

***Sarpanch*:** Elected headman in a village *Panchayat*.

***Holi*:** Festival of colors in March or April.

***Sarvodaya*:** Gandhian principle of triaged universal uplift.

***Jikolna*:** Water gathering festival that takes place at *Naadi*.

***Beri*:** Self-percolating ellipsoidal well.

CPR: Common Property Resource

PHED: Public Health Engineering Department

GRAVIS: Gramin Vikas Vigyan Samiti

VDC: Village Development Committee

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Abstract

The intention of this study is to provide a holistic look at the Naadi: a rain-fed common property resource used for drinking water collection in the Thar Desert, Rajasthan. A sustainer of human life in the Thar, Naadis have decided how and where residents of the Thar lived. This study examines both current and historical naadi use in the Jodhpur district of Rajasthan. The format of the study is a compilation and analysis of 15 field visits, a series of interviews, and investigation of recent alternatives to naadis. The success of a naadi is a function of geology, geography, and management. Management depends on a community's ability to guarantee ownership though participation. Declining management today can largely be attributed to the entrance of new drinking water technologies. An inverse relationship, however, cannot be assured between the rise of new technologies and the necessity of naadis in the future. In their current state, naadis are not being actively degraded; although, they are often neglected and misused. This study will not offer a definitive answer on the future viability of naadis; instead, it is meant only to be explorational.

Background/Introduction

A departure from my proposed topic of study must first be addressed. At the commencement of my independent study, it was my intention to examine the current state of common property resources (CPR) and their relationship with land management in the Thar Desert, Rajasthan. If it was determined that CPRs are being neglected, then a secondary task was to determine whether the revitalization of CPRs could be used to prevent land mismanagement. The extent of land mismanagement in the Thar can be explained as follows. The Thar, which occupies 62% the total surface area of Rajasthan, is home to 27.12 million inhabitants: approximately 40% of the total population of Rajasthan. The Thar features a population density of 136 people per sq. kilometer; this figure was misreported as being 86 people per sq. kilometer in my proposal. Both figures, correct and incorrect, reflect the highest population density of any desert in the world when compared with densities of 3-9 people per sq. kilometer in the Saharan and North Australian deserts (HEDCON, 2012). The region suffers from erratic rainfall of uneven distribution that appears in a west-east gradient ranging from 100-500mm of precipitation annually. The inequality of rainfall is evidenced by a local saying in the Thar: 'When it rains, one horn of the cow is wetted while the other horn remains dry'. Subsistence agriculture and animal husbandry are the primary occupations of residents. Livestock greatly outnumber people in the Thar, the number of livestock per capita is 10X that of the national average. The spatial constraints of the Thar, in conjunction with a predisposition to drought and high biotic pressure, result in overgrazing, deforestation, and intensive agriculture practices: this is what's meant by land mismanagement.

If land mismanagement results from scarcities of fodder, biomass, and cultivatable land, then CPRs (which can offer all these resources) appear to be a plausible solution. It was this assumption that directed my interest towards *Orans* and *Gochars*, both of which are dedicated community grazing lands. Nevertheless, the two are importantly different. *Gochars* are community lands that were designated following the rule of princely states. Prior to Independence, there existed well over 600 princely states in India by the year 1947 (Grey, 2017). After the dissolution of princely states, land ceiling laws prompted large land owners to donate land with the condition that it became village property. As such, *Gochar* land can be neither sold, re-allotted, nor cultivated. Enforcing punishment for violations of these rules was a job left to the local *Panchayat*. *Orans*, unlike *Gochars*, are private property; the ownership of which rests with a local deity. Since *Orans* are private lands purposed for public use, they are vulnerable to both allotment and disagreement on rules of use. Fuelwood harvesting, grazing, and fodder collection are all accepted uses of *Orans*. They are protected from encroachment by a communal fear of divine retribution and overseen by a priest who lives on the property. Given that *Orans* are the predecessor of *Gochars*, the responsibility of maintenance was left to the community as the *Panchayat* system had not been established yet.

My original proposal sought to determine the truth of the following assumption: If upkeep of *Orans* and *Gochars* is declining, then the socially accepted traditions that governed those spaces is disappearing. While this positive correlation is likely true, it ignores other conditions which dictate the use/disuse of CPRs in the Thar. The entrance of mechanized farming implements should be seen as beginning a causal chain of CPR deterioration. Before tractors became widely available, ploughing was done entirely by draught animals. An efficient alternative, tractors rapidly replaced cattle as agricultural tools. Accordingly, a change has occurred in the livestock favored by Thar residents. The common livestock preference is transitioning to smaller ruminants: namely sheep and goats. These animals have several advantages that cattle cannot offer. Neither sheep nor goats are selective grazers; in fact, goats are known as destructive grazers. Another folk saying in the Thar goes '*Oont Chhote Ankada, Bed Bakri Choode Kankada.'* A rough translation in English is as such: 'The camel leaves the Aak shrub. Sheep and goats leave only stones' (Jhunijhunwala, 2003). Additionally, goats can also be milked at any time of day, and their meat is appreciating in value. Sheep, of course, provide economic return through their wool. As of this year, Rajasthan produces 30% of India's goat meat and 40% of its wool, as compared with producing only 10% of its cow milk (Grey, 2017). Wealthy families living in the Thar have begun to raise buffalo as well. Buffalo have the same dietary requirements as cattle, but are more sedentary grazers than cattle are. Buffalo milk is a valuable commodity and it usually sells for 1.5X as much as cow milk. Buffalo milk is enriched with protein and contains 5-6% fat; cow milk has a fat content of around 4% (Dhir, 2017). The appeal of goats, sheep, and buffalo is explained by their minimal grazing requirements and high economic potential. Historically, community owned grazing lands have been maintained specifically for use by cattle. Cattle becoming less favorable is part of the reason for growing pressure to allow cultivation on CPR land. Secondly, the land under cultivation in the Thar is steadily increasing. The growth of net cropped area in the Thar can be lineated as such: 1956-57, 36%; 1981-82, 47.8%; 2010-11, 57.4% (Dhir, 2017). Legal statutes, however, prohibit reallocation of this land; consequently, the land is being used in its lowest capacity for hard grazing goats and sheep.

Solutions to the neglect of grazing area CPRs should focus on adjustments to the CPR itself, not a return to the original conditions under which the CPR was well-managed. Suggesting the elimination of tractors is neo-Luddist and economically nonsensical. The same is true for attempts to re-popularize cattle ownership. Instead, amendments to former grazing lands could come in the form of proactive tree cultivation. Malnourishment is a major threat in the Thar; as of 2013, 72.4% of rural children in the Thar suffered from anemia due to an absence of green vegetables in their diets (Sharma, 2010). Horticulture units, installed alongside existing vegetation in community grazing areas, could bring much needed micronutrients into communities. Farmers are often reluctant to plant trees, especially fruit trees, in their fields for fear that trees will obstruct in-field movement, attract birds, and compete for nutrients with crops. These concerns make tree plantation in grazing lands, where there is no risk to a single farmer's produce, more attractive. An endorsement of agroforestry is where I had hoped to arrive with my first topic of study. Indeed, agroforestry would likely be a good modification to disused grazing land CPRs. To discuss the viability of agroforestry, or of any agriculture for that matter, without first discussing water availability would be an incomplete assessment. Since it didn't consider the precondition of water availability, my exploration of CPR grazing land began to feel oversimplified.

It was at this junction that my change in trajectory occurred. An understanding of the current state of CPR grazing lands presupposes an understanding of water in the Thar. Local water availability in the Thar is deserving of study for several reasons. 50-liters of water per person is recommended as a global, daily standard. This quantity can be deconstructed as such: drinking water, 5L; sanitation services, 20L; bathing, 15L; cooking and kitchen, 10L (Mathur, 2013). This recommendation excludes the water requirements of livestock and agriculture, which are both highly variable. Average daily access across the rural Thar is 10 liters per person. An additional 20 liters is suggested for livestock in the Thar (GRAVIS, n.d.). This deficiency can be partially explained by a lack of waterways in the Thar. The Luni river is the only major waterway; it occupies 10.6% of the South-Eastern corner of the Thar (University of Rajasthan, Jaipur & Natl. Academy of Sciences, Allahabad , 1988). Fortunately, there is supplementary water delivery infrastructure in the Thar; albeit, infrastructure that often proves unreliable. Instillation of the Indra Gandhi canal, a massive two-stage irrigation project, began in 1955 and was completed in 1984 (Dhir, 2017). The length of the canal, from its genesis in Panjab, is 854 km^2. Although the canal is far-reaching, its original purpose is solely irrigation, not drinking water. Drinking water, as well as water for irrigation, is increasingly supplied by tube wells in the Thar. Tube wells, installed either by individuals or government agencies such as the Public Health Engineering Department (PHED) draw directly from the water table. According to India's Central Ground Water Board, dissolved solids in Thar groundwater are at 10,000 mg/L against a maximum allowance of 2000 mg/L. Similarly, fluoride is at 3 mg/L compared with a max of 1.5 mg/L, and nitrates reach levels of 745 mg/L compared with a max of 100 mg/L (Sharma, 2010). Concerningly, this report does not include a description of the surveyed area; this is reason for skepticism. The arid conditions of the Thar, in tandem with a water supply that is likely unsafe, should put increased importance on rainfall in the Thar.

To contextualize rainfall in the Thar, a few environment-specifics should be understood. Firstly, more than 90% of rainfall in the Thar is delivered during the summer monsoon (June, July, and August). Rainfall that decreases even 16% below normal monsoonal behavior can result in drought and scarcity (Sharma, 2010). This is further complicated by potential evaporation rates which *always* exceed rainfall in *all* areas of the Thar; these range from 1600-2000mm annually (University of Rajasthan, Jaipur & Natl. Academy of Sciences, Allahabad , 1988). The dominant sandy soil type in the Thar is characterized by high infiltration, but low unsaturated state hydraulic conductivity. This is the result of high porosity; this means that less moisture is available to vegetation. As such, moisture is not retained at shallower soil depths. The effect of these conditions would be less severe if there was more irrigation coverage in the Thar; however, only 25-27% of cropped area in the Thar is under irrigation today (Dhir, 2017). The production of the remaining areas depends on their ability to successfully trap the monsoonal rainwater.

Since rainwater collection is a shared interest among community members, it seems that land-use systems within a given area should match water availability in that area. On average, 2-4% of land in each of the Thar's villages is dedicated to a community resource (Jhunijhunwala, 2003). A disclaimer is necessary here: although my study 'departed' from its earlier focus on community owned grazing lands, my interest in CPRs has not undergone any diminution whatsoever. If anything, the search for a CPR that is more fundamental to livelihoods in the Thar has only amplified my interest. I have identified this fundamental CPR as being the *naadi*. *Naadis* are village ponds surrounded by a catchment area. The *naadi* basin collects potable water during the summer monsoon. The duration of water retention in *naadis* is not uniform. *Naadis* do not appear accidentally; rather they are engineered features. Although, *Naadis* are often built in conformity with existing topography which acts as a natural catchment. In the past, these village ponds have served as a reservoir of water for the consumption of both humans and livestock.

Naadis are central to historical life in the Thar; in fact, the placement of villages was often determined by the suitability of nearby terrain for a *naadi*. There a several villages in the Thar which have been continuously occupied for between 500-1200 years (Jhunijhunwala, 2003). These villages have at least one *naadi* per village incorporated into their layout. A baseline survey of potable water source dependence in the Jodhpur and Jaisalmer districts of the Thar reveals the following: *Naadi*, 64%; hand pumps, 12%; open tube wells, 8%; wells, 5%; *Taankas* (catchment filled cylindrical tank), 2%; other sources, 6% (Mathur, 2013). Since *naadis* have been, and continue to be, the foremost rainwater storage technology in the Thar, they demand in-depth examination. The continued use of *Naadis* suggests that they are being actively maintained. Ongoing maintenance is an indicator, if not a guarantee, that *naadis* remain an asset for some communities in the Thar. The next section entitled ‘Methodology’ will explore subsequent questions and the strategies used to address them.

Methodology

The first question that arises in my study of *naadis* is as follows: **(1. How were *naadis* traditionally maintained?** Perhaps the most qualified demographic to answer this question are elderly residents of the Thar. There is a disproportionate, and increasing number of elderly (65+) people in the Thar. To illustrate this point, 8 villages in the Jodhpur district alone have elderly populations of more than 92% (Mathur, 2013). If the past maintenance of *Orans* and *Gochars* is suggestive of general authority structures in the Thar, then elderly people may also play an integral role in policing *naadis*. Likewise, *Orans* and *Gochars* served as venues for religious festivals which strengthened the community’s dedication to the space. These ceremonies sometimes even involved extraction: fruit was taken from *Orans* on *Diwali* and wood was harvested on *Holi*. If comparable ceremonies took place, or continue to be held at *naadis*, then elderly people in the area can likely provide reliable descriptions. My findings include the interviews of 3 elderly people living near studied *naadis*, and two interviews of elderly members of the scientific community in Jodhpur. It should be noted that elderly interviewees in the field were asked a personal question about fluorosis. All interviewees voluntarily disclosed this medical information, and agreed to have it reported in the study. This question doesn't advance understanding of the first question; instead, it is more closely tied to the coming question.

The second question that my study attempts to answer is such: **(2. Will *naadis* continue to be a necessary technology?** A restatement of this question might appear in the following way: What modern water delivery technologies could replace the *naadi*? The answer to this question has serious implications for future study and investment in *naadis*. In the context of the Thar, the recent 'rival' technologies to *naadis* are canal irrigation and tube wells. Since my awareness of these technologies developed *during* my time in the field, related interviews were spontaneous. Lacking adequate knowledge about canal irrigation and tube wells, I was wary of being confused or misled during interviews. One such interview, during which I was not given accurate information, is reported in the coming 'findings' section. In such instances, it's more likely that the interviewee was repeating misinformation, not trying to skew my findings. My field advisor, Rajendra Kumar, was useful is checking the veracity of information taken from these unplanned field conversations. Rajendra's understanding of canal irrigation and tube wells is supported by his work with the Jodhpur-based NGO, GRAVIS, as a program coordinator.

This seems to be an appropriate place to introduce GRAVIS, the NGO which acted as the facilitator of my field work. Established in 1983 by L.C Tyagi, GRAVIS is committed to the upliftment of vulnerable communities living in the arid zone. A founding tenet of GRAVIS is the Gandhian principle of *Sarvodaya*; this is best described as 'all rising, but last rises first'.

GRAVIS realizes this principle by targeting its interventions at communities with the greatest demonstrated need. Since its founding, GRAVIS has expanded its area of operation to over 350 villages throughout the Thar. Beyond its commitment to humanitarian work, I am impressed by GRAVIS' willingness to provide me with the accommodations and connections necessary for my field work. GRAVIS, being an NGO, isn't restricted by governmental red tape. I did not need to obtain permission from any central ministry before coming to the GRAVIS headquarters in Jodhpur. After a weeklong stay in Jodhpur, GRAVIS arranged for my room and board at a training center in the village of Jelu Gagadi. Gagadi, located approximately 60 kilometers from Jodhpur proper, was treated as a base from which I conducted my field work over the span of two weeks. GRAVIS also arranged transportation for me on one occasion. Without the assistance of GRAVIS, investigation of my next two questions would have been much more difficult.

Even though the following two questions are distinct, their answers are retrievable by the same methods. One question is: **(3. Under what conditions does a *naadi* have the highest output?** 'Output' should be taken to mean the amount of time that water stays in a *naadi*, in addition to the cleanliness of that water. The other is: **(4. Does current *naadi* maintenance reflect continued necessity?** A possible criticism of the question itself is that (.4 depends on an affirmative answer to (.2. The answers to both (3. And (4. are discoverable by observation. During my time at Gagadi, I traveled to 15 different *naadis*, all of which were in the Jodhpur district of the Thar. Detailed notes including descriptions of wildlife, vegetative cover, land forms, geology, hydrology, signs of upkeep, and superstructure were collected at each site. Physical samples were taken from each site as well. Samples are either rock fragments or dried silt collected from the bottom of the *naadi* basin. Occasional engagements with people around the site are also documented. These engagements must be scrutinized since people are careful not to self-incriminate when discussing their use of the *naadi*. It must be mentioned that the data from 3 sites has been omitted; accordingly, only the data from 12 sites is present in the 'findings' section. These sites were too similar, both in location and formation, to be relevant to the study. Finally, there is a likelihood that conclusions drawn from these findings will (to some degree) commit the fallacy of 'unrepresentative sample'. Given the amount of time allotted for my study and the enormous number of *naadis* in the Jodhpur district alone, encountering this error was inevitable.

Findings

To make this data more accessible, my findings have been categorized by the question(s) that they contribute to. Each question is stated in bold font and the corresponding field data is listed below it. As discussed in the previous section, questions (3. & (4. will appear together as one heading. All data collected directly from *naadis* is encompassed by this heading. *Naadis* have been designated letters 'A'- 'L' for the sake of brevity.

(1. How were *naadis* traditionally maintained?

My first contact is with a man who identifies himself as Bansilal; he is leading sheep through the *naadi* at Jelu Gagadi. He reports being a long-term resident of the area and says that his age is 70. According in Bansilal, water disappears from the *naadi* two months after the cessation of monsoon rains. He suggests that in earlier years, water remained in the *naadi* for four months after the end of the monsoon. When asked about the extent to which *naadi* use is regulated, Bansilal says that some rules are no longer enforced. He comments that 25 years ago livestock were neither allowed to sit in the catchment area nor in the basin of the *naadi* itself. Formerly, extraction from the *naadi* was allowed only at designated sites along its banks. He described a festival, spelt phonetically as *Jikolna*, which has since vanished. During this festival, sisters and brothers would congregate at the *naadi*; men would take pitchers of water and present it to women, who would wash their faces. Asked about de-siltation of the *naadi*, Bansilal says that government contractors will arrive during the winter time and excavate the *naadi* with the help of volunteers. This work is, according to Bansilal, totally dependent on the *panchayat* budget which is sometimes insufficient. In response to my question about fluorosis, Bansilal says there is no presence of the disorder in the area.

The next elderly person interviewed is Mangla Ram; he is 87 years old and lives in the Bhalou area. Despite being a resident for the past 50 years, he was not born locally. Surprisingly, he says that his family has never depended on the nearby *naadi*. He attributes this to not owning any livestock, aside from a single cow. He lives on the land that he cultivates, and notes that water for irrigation and drinking alike comes from a tube well located on his property. This tube well is not connected to a sprinkler system; at least, there is none in sight. While touring his fields, a thin white-silver film is visible on the soil surface. This film has minimal coverage and appears to be randomly distributed. When questioned about the film, Mangla is dismissive and says that it doesn't interfere with crop production. During the tour of his property, Mangla's mobility seems to be impaired. He claims to suffer from arthritic joint pain. Mangla denies having an history of Fluorosis.

While in the Baap area, I meet with Inder Singh, a liaison for the local elderly council. Inder is just entering his seniority, but functions as a representative for the senior community in local government. Inder says that authority structures in the Thar have seen significant change in the past half-century. He indicates that elderly members of the community used to oversee upkeep of *naadis*. They were invested with the authority to punish encroachment by imposing fines and/or other forms of compensation. Alternative compensation usually involved a donation of grain. In cases of repeated offenses, a commission of elderly could order exclusion from the community altogether. He said it was rare for verdicts, even severely punitive ones like exclusion, to be challenged. This compliance he credits to the high respect formerly given to the elderly. One *naadi* in the Baap area is famous for never going dry, even during intense droughts that spanned the years 1987-90 and 1999-2003. Inder explains that groundwater in the Baap area is too saline to consume; resultingly, the *naadi* has always been of critical importance for the surrounding community. Given that groundwater near Baap is altogether undrinkable, Inder says that the elderly community is not at a risk of fluorosis. Groundwater is, of course, the source of fluoride.

Dr. J.P Gupta, a retired CAZRI scientist whose career emphasized water management, discussed *naadi* maintenance with me in Jodhpur. He spoke to the social dimension of *naadi* use, which was otherwise unexplored by my study. Social hierarchies have historically been pronounced in the Thar, and caste distinctions were used to determine a group's eligibility to use a *naadi*. Gupta indicated that within a single area in the Thar's past, there may have been small catchment ponds which belonged to specific castes. The exhaustion of these ponds usually coincided, and at an agreed-upon time the different castes would abandon their unique ponds and converge on a centrally located *naadi*. Gupta was intentional in saying that this annual event didn't occur in every village across the Thar. He says that universal access to community water sources in transitioning *in*; although, it is a gradual transition. A final interviewee, Dr. S.M Mahnot, who has had a long association with the School of Desert Sciences in Jodhpur, was adamant about an increasing misuse of *naadis*. Mahnot attributes this to what he calls a 'degeneration of thought in the people'. The primary feature of this 'degeneration', according to Mahnot, is the abandonment of religious devotion which once bound people to *naadis*. Mahnot claims that *naadis* might not be altogether neglected, but they are not being expanded proportional to increasing biotic activity.

(2. Will *naadis* continue to be a necessary technology?

The field data relevant to this inquiry will be formatted as a comparison. The first characterization of tube well and canal use in the Thar comes from a member of the administration at *Bijaria Bawari* school in the village of Jeloo, Jodhpur district. This person, who preferred to remain anonymous, claimed a high degree of familiarity with water systems in Jodhpur district. Rajendra Kumar was asked to provide a separate characterization of tube well and canal use. There is some confliction between the information gathered from the anonymous interviewee and Rajendra. In this section, all information will appear as reported without any evaluation of its truth value.

The school to which the anon. administrator belongs is located no more than 50 meters from a large lined canal. Anon. claims that this is a section of the Indra Gandhi: the function of which is exclusively a drinking water supply. Extraction directly from the canal is illegal; instead, water must be taken from filtered reservoirs. Anon. alleges that the canal contains fresh mountain runoff from the Himalayas. The canal is subject to frequent water quality testing and the government is diligent about repairs. When asked about the supply of PHED water tanks in Jeloo, anon. points to the Indra Gandhi as their source. Anon. says that the installation of tube wells is also advantageous in the area since groundwater is not highly saline. Anon. mentions, however, that the government emplaces restrictions on tube well use by limiting daily electricity.

Since there is water movement during all months of the year in the canal and since tube wells are viable, both *naadis* and Nehru-era hand pumps have become obsolete.

From his involvement with GRAVIS, Rajendra is also familiar with the section of the canal being discussed. Rajendra supplies the following information. While extraction at undesignated sites is formally illegal, it is occurring at a high frequency. Water that has been extracted in this way has not undergone treatment yet and is unfit to drink. The source of canal water *does* originate from the Himalayas, but it is glacial meltwater instead of rainwater. Due to runoff contamination, canal water that is procured illegally can only be used for irrigation: its largest unofficial application. PHED water tanks are not filled by the Indra Gandhi; they are fed by tube wells. Depending on the condition of local groundwater, PHED tanks may be connected to tube wells as far as 15 kilometers away. Additionally, Rajendra cannot locate any of the described 'filtered reservoirs' in the Jeloo area.

(3. Under what conditions does a *naadi* have the highest output? &

(4. Does current *naadi* maintenance reflect continued necessity?

*Measurements of height and distance included under this heading are all approximate. As previously mentioned, each *naadi* has been assigned a letter 'A- L' as a placeholder.

A. The *naadi* described below is located within walking distance of the training center at Jelu Gagadi. It is the same location where my contact with Bansilal occurred. Not all information about this site is observation-based; some details were communicated by Bansilal. **A** is bordered on one side by a roadway; this road becomes inundated and consequently impassable during the summer monsoon. The rear side of **A** is defined by barbed wire fencing, on the other side of which is farmland. A 3-meter-high berm encloses 200 meters of **A**'s perimeter. The berm has a gradual slope and is constructed of clay/silt layered above a preexisting rock face. Exposed parts of this rockface contain what appears to be quartzite. The berm is interrupted by an entrance canal. Within the basin, a trench with a depth of 1 meter has been dug at the foot of the berm; this connects to the entrance canal. The berm is vegetated primarily with *Acacia tortilis*. The basin is covered in *gaas* weeds and is also occupied by 4 *Prosopis cineraria* (*Khejri*) trees. There is a substantial amount of garbage concentrated on the top and sides of the berm. The basin is less littered, but is covered in sheep/goat droppings. Seven cattle were grazing on pre-cut fodder in the basin. Cracked silt covers depressions in the basin, but is not present in higher areas. There is no water present in the basin. A return visit to **A** two weeks after the initial date of observation reveals three small excavation sites within the basin. All three sites are placed in depressions where silt is present. Each has been excavated with machinery as evidenced by tractor tire impressions in the ground.

B. **B** is located a five-minute drive away from the village of Jeloo. The catchment is entirely rock. Just under half of the total catchment area is surrounded by artificial sidewalls which are made of stone as well and reinforced with tall vegetation. The naturally-occurring rock appears to have undergone significant weathering; it is bulbous and rounded. There is also loose sediment overlaying the rock that dominates the surface of the catchment. Particulate size increases with distance from the center of the basin. In the center of the basin is a patch of water 10-15 meters across; this is a habitat for countless small frogs. The center of the basin shows evidence of heavy animal traffic, and there are cattle present on the edge of the catchment area.

C. **C** is located on the outskirts of the village of Bhalou. **C** has a loose gravel catchment; the composition of which matches the surrounding rocky hills. The entire catchment is a uniform rock-type, but some rock has reddish discoloration. There are animal tracks, droppings, and a deer is spotted inside the catchment area. A berm with moderate vegetative cover, including a few *khejri* trees, insulates the catchment from a crescent-shaped access road. There is neither silt, garbage, nor any vegetation inside the basin. **C** is completely dry at the time of my visit, but a local beneficiary tells me that water lasts in the basin from June to October. The same informant says that bathing in **C** is not allowed, and that the catchment is cleaned annually in June prior to the arrival of rain. My attention is directed towards a pipeline which transports water from **C** to the storage tank of a nearby school.

D. **D** is a continuous sandy depression which is accessible directly from the road which leads into Bhalou. Easily mistaken for a dry riverbed, **D** extends for nearly 8km. Water is only retained for three months of the year. One bank is lined with *khejri* and *Tecomella undulata* (*Rohida)* trees; these are being browsed by camels during who are unperturbed by my visit. The opposite bank is reinforced with a stone berm. The berm has been installed by GRAVIS and provides protection from inundation along 3 kilometers of **D**'s length. These 3 kilometers are reportedly farmed by close to 50 farmers. Since its shoreline descends into the water at a gradual slope, community members water their goats on banks of **D** while rainwater lasts. Although little trash is present in the basin, there are numerous tire marks.

E. **E** is formed by two conjoined *naadis*; they share a spine-shaped berm which directs water into both basins. They are built to adhere to the surrounding contours: all of which are rock faces. Given **E**'s location no more than 15 kilometers from the previous two *naadis* described in this section, **E**'s Rock-type is the same igneous, reddish rock. Interestingly, the rock at **E** has not been weathered into gravel; instead, it protrudes from the soil in smooth slabs. Gravel is more abundant at higher elevation on the surrounding hillsides, and it has been displaced by the movement of water into **E**'s basin. At the time of the visit, there is no water present in either of the conjoined *naadis*. Another deer is spotted inside the basin of **E.** Grass within the basin displays clear signs of grazing; it is difficult to determine if it has been consumed by livestock or wild animals. A full-sized tree has been harvested (by humans) on the edge of the catchment. **E** contains two very young *naadis*, established only 50-60 years ago. The larger of the two is enclosed by a dirt berm that was reportedly constructed by GRAVIS 20 years ago.

F. **F** is located only 2-3 kilometers away from the first site visited in the Bhalou area, **C.** Here, GRAVIS has created a *naadi* in conjunction with a 50-acre plot of *Vachellia tortilis* (Israeli Babool) that was intended to be a grazing space for cattle. **F** is comparatively small in perimeter, but has a depth between 4-5 meters with an abrupt slope. The catchment around **F** is fortified with concrete. Surprisingly, much of this concrete has been gouged into channels by movement of water towards the basin. There is a vegetated berm that encloses about 30% of the total perimeter. The basin of **F** is completely dry and has been used as a dumping ground for glass bottles and plastic products. Further exploration around the site reveals more heaps of discarded glass bottles, in and around the catchment area of **F.**

G. **G** is the final *naadi* visited in the Bhalou area. It was constructed in 2001, and it features more superstructure than any other *naadi* I have examined. Nearly ¾ of **G** is encircled by a 6-meter-high berm; the design of which incorporates both cement and stone. There are two flights of stairs which descend to the waterline; they are positioned on opposing sides of the basin. Water is present in the basin and it appears relatively free of particulate. Water is retained in **G** for 10 months out of the year. The bottom of **G**'s basin is dehydrated silt that is interspersed with *gaas*.

There is also a depth marker with illegible markings emplaced in the basin. Beginning at the base of one staircase, silt has been strategically removed and de-siltation is presumably ongoing. It has been done mechanically, and tractors have been driven in the basin.

H. **H** is located near the village of Bhadi Dhani. **H** is surrounded by a vast gravel catchment with a gentle grade; it is free from debris and waste; albeit, there's excessive amounts of animal droppings. There is a single primary entrance canal. *Prosopis juliflora*, commonly known as Mesquite in English, has been removed from the catchment and is consolidated into piles. Several mature *khejri* tress grow along the waterline on the opposite bank. Darkening near the base of these trees is suggestive that water levels exceed their position at the time of my visit. Reportedly established 200-300 years ago, **H** retains water all year long. Frogs and water fowl are abundant in the basin. **H** was revitalized by a GRAVIS de-siltation effort in 2003. Today, **H** is visited by approx. 600 goats/sheep, 200 cows, and 100 camels every morning. Local farmers also collect between 5-8 5000L tankers of water from the **H** each day. These numbers were given by a beneficiary of **H** who was asked to approximate daily usage. The same beneficiary explains rules of use: water is for domestic use only, not sellable; no defecation in catchment; no bathing or washing of clothes; livestock can drink, but are not allowed to sit in catchment. Violations of these rules are punishable by beating or by compulsory repayment. Clearly visible is a stone pillar which has been embedded in the gravel catchment. This pillar is inscribed with warnings of divine punishment; it threatens that a curse will befall the family of potential encroachers.

I. Located on the outskirts of the Baap area, **I** is known as *Dhartasar Talab*. The depth of **I** is reportedly 20 feet deeper than the previous *naadi* last. Similar to the previous *naadi*, it holds water all year round. **I** doesn't possess an expansive gravel catchment, however. **I** is enclosed by a flat-top berm, vegetated with *Acacia tortilis*, that has been strategically fortified on the downside to resist pressure from incoming rainwater. A meter-high mortared stone wall provides this fortification. The wall is inlaid with staircases at two locations. Cattle and waterfowl are both present in the basin of **I.** My attention is directed towards a rule board that GRAVIS has emplaced. It prohibits bathing, defecation in catchment area, and cutting of green trees. It also threatens a fine of 500 rs. for violation of these rules, enforced by the local panchayat and Village Development Committee. Since a GRAVIS intervention in 2003, the maintenance of **I** is done exclusively by community members. When **I** is desilted, the extracted silt is used for strengthening the existing berm. A stone pillar on the far-side of **I** declares former rules of use.

J. **J** is located close to the town of Tinwari. The basin is naturally formed by the convergence of two hillsides, both of which have exposed red rock on them. A berm has been built opposite the hillsides. The integrity of the berm, however, is compromised by deep erosive ruptures. Approximately 10% of the berm has been lined with flat stones; this bracing secures the corner of the berm against an adjacent channel which either acts as an in-route for rainwater, or as a spillway for excess water. The portion of **J**'s basin closest to the berm is cracked sediment, but the basin becomes grassier with distance from the berm. **J** is completely dry, and there is evidence that de-siltation has occurred. A tractor has clearly been driven into the basin, and small amounts of surface material have been removed. Interestingly, there are some exposed rock faces in the basin which show tubular holes: evidence that explosives have been inserted in the past. Any rocks that were unearthed explosively have since been removed.

K. Traveling in the direction of Osian from Tinwari, **K** is visible from the road. The roadbed creates a downslope into **K's** small basin. On the side of **K** that does not parallel the road, a small gravel bund has been erected: it may be 2/3 of a meter high. The gravel used for bund construction is the same that constitutes the surrounding catchment. This catchment is in the path of runoff from a nearby hillside, and is vegetated primarily with *Calotropis procera* (aak). The bathymetry of **K**'s basin is uneven, and shows signs of recent excavation. The basin is of a white silt composition. No water is present; nevertheless, the silt retains the hoofprints of cattle from when the bottom of the basin was still malleable.

L. **L**, the *Dukiya Kidina naadi*, is in an eastward direction relative to Tinwari. **L** was the subject of a 2001 clean-up effort lead by GRAVIS. More than half of **L** is enclosed by the largest berm I have seen. It is approaching 10m in height and is a composite of silt and gravel. It slopes gently towards the basin, but declines sharply on the other side. There is no garbage visible in the catchment, or the basin itself. The top-side of the berm is bare of vegetation, but the shoreline is forested with *Capparis decidua* (*Kair*) and *Khejri*. A *Ziziphus Jujuba* (*Ber)* tree is enshrined in a stone planter amongst the other trees. A flock of waterfowl which resemble geese are present, and cows graze pre-cut fodder on the other bank. The water **L** is a turquoise color and is reportedly drinkable without any treatment. While I am taking notes, a 5000L tanker arrives and collects water. A man tries to clean his shoe in the water and is berated by the driver of the tanker. When asked about the reaction of the driver, the guilty party responds that the 5000L was being collected was for drinking purposes.

Discussion

Consistent with the format of the ‘findings’ section, the following section will be organized around the four questions that my study attempts to answer. Analysis of findings will be divided in such a way that each question receives due attention. It should become immediately apparent that the answers to all four questions interdepend; consequently, the pairing of findings and questions will be rearranged in this section and will not appear in the same order as above.

(1. How were *naadis* traditionally maintained?

The upkeep of *naadis* in the Thar’s past has been a sacred communal responsibility. Since this discussion will rely on the evocation of religious language, three distinctions must be made regarding use of the word ‘religious’. Firstly, something can be labeled ‘religious’ if that thing posits the existence of the supernatural; moreover, the ‘religious’ thing in question must be transcendent of earthly mechanical law. The stone totems present at *naadis* **I** and **H** are examples of artifacts which can be considered religious in this sense. Intended to protect the *naadis* from misuse, the efficacy of those totems depends on a subscription to superstition. If the theoretical perpetrator is convinced that over-extraction from the *naadi* will confer bad fortune on his family, then he is likely to be discouraged from over-extraction. In this way, fear maintains the balance between self-interest and public action.

Secondly, a practice can be described as ‘religious’ if it involves a high degree of observance from people who uphold the practice. Consider the festival of *Jikolna,* formerly held at *naadi* **A** in Jelu Gagadi. Regardless of any denominational association, this type of festival promoted participation from the community. Another such example is the historical cleaning of *naadis* on the moonless night of *Diwali* (HEDCON, 2012). In both cases, belief was less important than the ritual itself. It could be argued that belief and ritual, in this context, are inseparable. I would content that community-wide attachment to a *naadi* is reinforced more so by the physical gathering of community members than by the strength of individual devotion. Even if physical 'togetherness' is the combined expression of individual devotion, I would like to emphasize that 'religious' can mean secular observance of ceremony.

Third, 'religious' can refer to a measurement of investment. Imagine then, that the drinking water needs of an entire village rely on a single *naadi* during the dry months. Theism aside, a shared desire for survival becomes a new sort of religion in the community. 'Religious' maintenance of a *naadi* can be action motivated by a recognition of necessity. The role of the elderly in looking after *naadis,* described by Inder Singh, likely emerges from this necessity. The elderly possess not only the procedural knowledge that enables a *naadi* to remain productive, but also the wisdom of past water insecurity. Prior to the arrival of the institutionalized *panchayat* system, village headmen in the Thar had to obtain permission from village elderly before ordering punitive action (Jhunijhunwala, 2003). The diminishing role of elderly in the functioning of Thar villages coincides with a decreasing awareness of the necessity behind community-owned rainwater harvesting.

(2. Will *naadis* continue to be a necessary technology?

It should first be clarified what is meant by 'a necessary technology'. The description of *naadis* as necessary technologies relies a platitudinal conditional: If a source of drinking water is constant and available to everyone without unreasonable expenditure, and if it is the *only* source of drinking water in a given area, then that source of water is necessary. The future necessity of *naadis*, therefore, depends on the availability and reliability of other sources of drinking water. Two such sources in the modern Thar are tube wells and water canals.

Tube wells are an emergent technology in the Thar which has gained enormous popularity. In its infancy, tube well installation was expensive; it has since become much less costly. Tube wells are not interconnected by sub-surface piping; instead, each well is bored directly into the water table below. Groundwater quality in the Thar varies considerably depending on location. Between 40-45% of groundwater in the Thar has saline to highly saline content (HEDCON, 2012). The risk of salinity has more coverage than the risk of fluoride contamination in the Thar's groundwater. Fluoride contamination correlates with a fluoride/nitrate heavy belt that's situated 120 kilometers North-East of Jodhpur proper (Dhir, 2017). Where it is present, fluoride renders groundwater undrinkable. Ingesting fluoride with any regularity can result in fluorosis: a disorder associated with severe joint pain and immobility. Both symptoms are the result of fluoride accumulating in and around joints. It's reported that 42% of surveyed elderly persons living in the Thar suffer from some type of arthritis (Mathur, 2013). The symptoms of fluorosis could, without proper medical consultation, be mistaken for arthritis: this is what prompted my interview question regarding fluoride consumption.

Contrary to the information provided by the administrator at *Bijaria Bawari* school, PHED water tanks are indeed filled by tube wells. If potable ground water is not available directly below a PHED tank, then it will be carried by pipeline from a neighboring area. The administrator was correct, however, in his assertion that the government attempts to regulate tube well use. In fact, both state and central governments have been trying to do this for more than twenty years. Most attempts have failed since local politicians, concerned with their own popularity, refuse to enforce regulations. Tube wells require a three-face electrical connection to run; today, the government limits the supply of electricity to 6 hours daily. This restriction is out of concern for the rapid exhaustion of groundwater caused by tube wells across the Thar. Groundwater is now depleting at a rate of 1-2 meters annually in the Thar. If depletion continues at this rate, it is predicted that the area capable of supporting tube wells will begin to decline in five years (Dhir, 2017). Less groundwater available for extraction is the obvious result of tube well use. Another subtler consequence must be understood as well. Groundwater salinization occurs when infiltrating water weathers sub-surface rock and transports soluble salts to the water table. Increasing the depth of the water table exposes more subsurface rock; therefore, water must percolate further to reach the water table. More percolation time translates to more dissolved salt; put simply, over extraction from tube wells will have the long-term consequence of increasing groundwater salinity.

Since groundwater depletion will continue, at least temporarily, methods of groundwater recharge should be explored. *Naadis*, being large holding basins with semi-permeable bottoms, contribute to ground water recharge through seepage. Of the total water loss from 100 *naadis* surveyed in the Nagaur district, seepage accounted for an average loss of 36% from each (Joshi, 1981). Of course, *naadis* are designed to eliminate seepage as much as possible. Even though it is favorable in combating falling groundwater levels, *naadi* seepage does not even approach full restoration of extracted groundwater. Leakage from irrigation canals has the potential to recharge groundwater as well; although, this can have undesirable effects. Holding channels dug into farmland in the Thar are estimated to lose nearly 50% of their water input through deep percolation (Dhir, 2017). While moving downwards through the soil stratum, irrigation water can leech nitrates from the soil; these nitrates are retained in the water table. If water encounters an impermeable layer during its movement through the soil, there is a risk of waterlogging and soil salinity. This risk is intensified by the practice of flood irrigation which often overwhelms the absorptive capacity of soil. If water collects within 2 meters of the soil surface, then there is upward movement due to surface evaporation. Residual salts linger around root systems and appear on the topsoil (University of Rajasthan, Jaipur & Natl. Academy of Sciences, Allahabad , 1988). This is a likely explanation of the white-silver film observed on Mangla's property. In Mangla's defense, overwatering may be encouraged by uncertainty about future water availability.

Recharge of groundwater cannot be discussed without acknowledging possible leakage from the Indra Gandhi canal. An unlined canal of this size would contribute significantly to groundwater recharge; however, the entirety of the Indra Gandhi has a cement lining. Accordingly, losses from seepage are very low when compared with losses from evaporation. Although some details about the canal's construction were mentioned earlier, additional information is needed. Within Panjab, the Indra Gandhi begins at the confluence of the Sutlej and Beas Rivers. These rivers are fed by glacial meltwater tributaries; this makes the flow of the canal entirely vulnerable to accelerated glacial melting. A 204-kilometer-long feeder canal transports meltwater out of Panjab; after which, the feeder is received by the main canal, extending for another 649 kilometers (Dhir, 2017). After it became operationalized, the canal was only intended for irrigation; the *Bijaria Bawari* administrator failed to mention this. Water was, and continues to be, directed to rural areas through a series of branches, subbranches, and minors. This arterial system delivers water on a rotational basis of every 1-2 weeks. A local revenue official allocates water to farmers on a basis of landholding. It wasn't until Jodhpur industries began to flourish that the canal was repurposed for drinking water. The section of canal passing by the school of *Bijaria Bawari* was misidentified. This is a part of the Rajiv Gandhi lift scheme which carries drinking water to

Jodhpur. The dominant elevation for the main canal is 80 meters above sea level; Jodhpur is positioned at over 200 meters above sea level (Dhir, 2017). Communities living around the lift scheme are disallowed from extracting water for irrigation and drinking alike.

There exists a visible trend in the scale of farming operations along the Indra Gandhi where canal water *is* available. These locations are more likely to be sites of commercial agriculture than sites of subsistence farming. It could be said that the canal enables a transition from the later to the former, *or* it could be said that the canal is used disproportionately by the former, limiting access to the later. This trend is illustrated in the Indian context nationally: 65% of rural Indian populations live in areas dependent on rainfed agriculture; despite this, nearly 70% of the central governments annual expenditure on agriculture targets areas that already are under irrigation" (Grey, 2017). A notable socio-economic trend is apparent in tube well use also. Recently, individuals without agricultural land will install a tube well on their property and employ a driver to deliver 5000L tankers of drinking water to nearby families. There is a medium cost associated with purchasing this water, enough to make it unavailable to local families living in poverty. Given that both tube wells and canals in the Thar are costly and unrenewable sources of drinking water, their availability and reliability should be called into question. *Naadis* remain a 'necessary technology' since neither tube wells nor canals cannot be proven to be sufficiently 'available and reliable'.

(3. Under what conditions does a *naadi* have the highest output?

The geography and geology of an area surrounding a *naadi* can be used as sizable predictors of the *naadi*'s success. After all, there is an area south of Bahmer where no *naadis* exist due to terrain that is dominated by high porosity dune slopes. As a general rule, there is an inverse relationship between porosity size and water retention in *naadi* basins. The same survey of *naadis* in the Nagaur district previously cited shows that while sandy areas suffer from an average seepage loss of 36%, the loss from rocky terrain is only 21% (HEDCON, 2012). Consider that **D** had the shortest water retention among all the studied *naadis*. **B, E,** and **J**, conversely, were characterized by protrusions of slabbed rock with reddish coloration. At first, I mistook the coloration for rust. Only ferrous rocks rust; that is, rocks that have an iron content. An iron content is indicative of igneous formation. Volcanic activity did have a substantial role in the formation of the Thar's landscape, after all. Between 800-700 million years ago, lava domes about 250 kilometers south of Jodhpur were covering the area in Rhyolite (Rhyolite is a silica glass; it is often smooth and glossy in appearance, this is the result of a quick solidification time. Granite, another abundant igneous rock-type in the Thar, is given its distinctive appearance due to a more gradual cooling time that allows its crystals to marbleize. The coloration of the rock in **B**, **E**, and **J** is somewhat deceptive, however. Close examination of the rock reveals an aggregate composition; that is, it is imbedded with fragments of other rock-types. This is primarily sandstone, a sedimentary rock, inlayed with some metamorphic rocks such as the quartzite discovered at **A**. The deposition of the sandstone layer in the Jodhpur area is dated between 700-500 million years ago. Sandstone is now being extracted all throughout Jodhpur district using pit mining; the explosives used in **J** were likely for that purpose. During the *Quaternary* period, which began 2.6 million years ago and continues today, alluvium and blown sand covers the earlier igneous and sedimentary depositions. Alluvium refers to weathered sediment which has been brought into suspension and redistributed by water. Much of this weathered sediment in the Thar formerly was constitutive of the Aravalli hills located in the north-east.

An understanding of geologic history, even a simplified one like that presented in this paper, is needed for a complete picture of *naadi* functioning. The composition of the catchment area that surrounds a *naadi* determines how much sediment enters the *naadi*; consequently, how often de-siltation is necessary. Since particulate size determines erodibility, the runoff from older alluvial plains and gravelly terrain carriers the greatest amount of sediment. The gravel berm of **K**, and the annual cleaning requirement of **C** exemplify the relationship between high rates of siltation and rocky catchments. Excessive removal of silt from *naadi* basins, that is removal with a frequency greater than every 4-8, years is not recommended. Silt acts as a natural barrier against seepage; for this reason, a silt lining with a thickness of 10 cm should be maintained (HEDCON, 2012). Unwanted build-up of silt in *naadi* basins is damaging as it accelerates the process of surface water evaporation. Intuitively, siltation in a *naadi* basin is capable of reducing the volume of the basin. By damaging the holding capacity of the basin, siltation interferes with the surface area to volume ratio of the basin. CAZRI advises a surface area to volume ratio of .25-.28 (HEDCON, 2012). Assurance of this approximate ratio is, in part, what makes water retention in **V**, **H**, and **I** so great. An attempt to engineer this ratio can be seen at **F**, which was only recently excavated by GRAVIS. Vegetative cover also is multifunctional, both as a silt trap and a guarantor of decreased wind velocity. Too dense of vegetation in a catchment area can obstruct the movement of runoff into a *naadi* basin; an intermediate amount placed around the shoreline is desirable. The proximity of vegetation to the shoreline, as observed at **L**, limits the amount of air circulation directly above the *naadi* basin. Recently evaporated water lingers above the basin forming a miniature low-pressure system. The dissipation of this system and resulting entrance of low-humidity air increases the rate of evaporation.

(4. Does current *naadi* maintenance reflect continued necessity?

Obviated by my findings, the answer to this question is location specific. In the Baap area, where groundwater is too saline for human consumption, *naadis* **H** and **I** are maintained in conformity with their traditional maintenance practices. These *Naadis* are valuable insofar as alternatives do not exist. They are routinely desilted every 5-6 years; de-siltation is a community wide effort during which locals work in shifts of 50-60 people. This is the critical type of physical ‘togetherness’ emphasized earlier. The scale of de-siltation in a *naadi* can be taken as a reliable proxy for the value assigned to the *naadi*. Consider *naadis* **K**, **A**, and **J**; these sites exhibit signs of disorganized, personal-use de-siltation. When de-siltation is conducted by an entire community, the extracted silt is layered onto the existing berm wall as fortification. Extracted silt is attractive for domestic reasons too; that is what’s meant by ‘personal-use’ de-siltation. Reconstituted silt can be used as a construction material for homes and outdoor hearths. Additionally, it can be distributed on farm fields as a rich fertilizer. Maintenance, if it can be called that, at **K**, **A**, and **J** is only being done for the benefit of a single family. Likewise, the threat of beatings and the imposition of fines at **H** is not a result of the community’s reliance on the *naadi* for drinking water. The daily traffic of livestock at this *naadi* is now what gives it value. This is a common theme at many village ponds across the Thar. Ponds are used increasingly for watering livestock, and this becomes their default purpose due to the contamination caused by prolonged presence of livestock. Despite rules that prohibit livestock sitting in the catchment, fodder that has been harvested elsewhere has been brought along with livestock to **A** and **L**. Even the motivations for the tanker driver's mutual coercion at **L** should be called into question. Perhaps he is sincerely interested in protecting a community water source, or perhaps he is just looking out for a lucrative business interest (refer to question 2 in 'discussion' section). Moreover, unless no other drinking water alternatives are present, *naadis* are valued only to the extent that they are a non-need-based extractable resource.

Conclusions

Community-wide neglect of a *naadi*, at face value, seems like a blameworthy offense. Condemnation of these communities, however, should be subdued by further thought about the four questions explored in this paper. Since traditional *naadi* maintenance relied on community participation, the mediums used to ensure participation must be considered. It's easy to understand how the first medium, a fear of god, deteriorates when encroachers are repeatedly seen by the community not being punished. The second medium, ritualism, declines as community members must work more to secure livelihoods; the rise in wage-labor and migratory livestock rearing are important here. The third medium, acknowledgment of necessity, vanishes altogether when other sources of drinking water are introduced. Given the discussion of other drinking water technologies in the Thar, it's tempting to say that people's distancing from *naadis* lacks foresight and arises from a hunger for convenience. A visual of women walking long distances while balancing water containers on their heads is useful in empathizing with the desire for convenience. There is little culpability in preference for tube wells and the Indra Gandhi; they are immediately better sources of drinking water than *naadis*. Assessing the *future* need for *naadis* is predictive in nature; as such, the assessment is subject to the principle of induction. Since, even at present, both tube wells and the Indra Gandhi are exhaustible and are not universally available, *naadis* shouldn't be altogether abandoned. Thankfully, the current state of *naadis* doesn't reflect total abandonment. It does, however, demonstrate upkeep that is comparable to that of *Orans* and *Gochars*: use at lowest capacity. This is worrisome considering that maintenance is easier than rehabilitation. While environmental factors do predispose the *naadi* to greater or lesser output, cleaning of catchment areas, regular de-siltation, and enforcement of *naadi* rules by beneficiaries determine how potable the water is. As stated in the abstract, this paper will not guess at the fate of *naadi* usage. My hope is for the reader to understand *naadis* as systems, albeit not self-sustaining systems, and to be equipped to make their own conclusions about the trajectory of *naadis.*

Recommendations for Future Study

For the sake of brevity, the following will appear in list format.

1. What technological improvements can be made to increase the output of a *naadi*? Concentrating on losses due to seepage, CAZRI suggests lining the *naadi* basin with a low-density polyethylene sheet. To prevent evaporation, an insulative floating cover is suggested. Can either of these technologies feasibly be put into production and made affordable?

2. For the sake of groundwater recharge, can a *naadi* be designed to release a controlled amount of seepage? This might be accomplished by maintaining a balance between excavation and compaction. Since the soil beneath a sheep's-foot roller or tractor tire is compressed, mechanized de-siltation and compaction could occur simultaneously.
3. *Beris* are sometimes dug into the basin of *naadis* and can be accessed as a reserve source after water in the basin has been exhausted. *Taankas* are occasionally placed on the perimeter of *naadis* as a means of purifying *naadi* water and assuring ease-of-access. Should the coupling of these technologies with *naadis* be expanded?
4. What is the current role of local governments (i.e. *Panchayats)* in enforcing *naadi* rules of use? It is rumored that candidates contenting a position, especially *Sarpanch*, will be lenient to win popular support.
5. Can a non-political group be established to monitor the use and upkeep of *naadis*? GRAVIS has emplaced Village Development Committees in some areas. VDCs advocate for the allotment of funds and can lobby outside organizations to help with *naadi* maintenance/revitalization.

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