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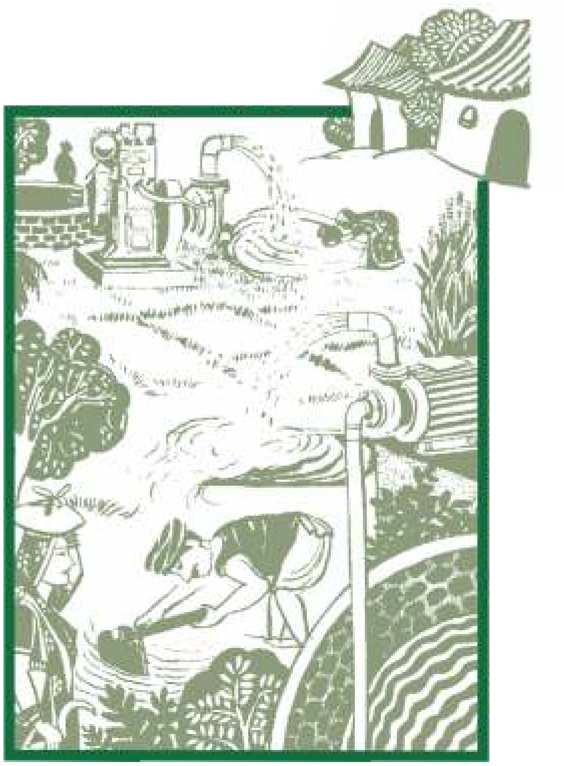

IWMI-TATA
Water Policy Program

Water Policy Research
HIGHLIGHT

Pipe assisted underground taming of surface floods

The experience with Holiyas in north Gujarat

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Holiyas (also known locally as *bhungroos*) are relatively simple, locally applied, groundwater recharge and subsurface storage systems and may hold the potential to mitigate exposure of smallholder farmers to floods and droughts. However, little verifiable knowledge is available on their performance and impact. In 2015, the IWMI-Tata Program undertook an assessment of *holiyas* and *bhungroos* in Banaskantha district to empirically analyse their socio-economic and environmental impact. The results suggest that majority of respondents perceive the structures' construction to be successful and report improvements with respect to one or more of the following criteria: flood mitigation, soil erosion, drought resilience, extent of the cultivation period, crop yield, cropping intensity and livestock rearing.

PIPE ASSISTED UNDERGROUND TAMING OF SURFACE FLOODS

*The experience with Holiyas in north Gujarat**

Research highlight based on Bunsen and Rathod (2015)

1. INTRODUCTION

Socio-economic development in groundwater-dependent agrarian socio-ecologies is tightly linked to the availability of water. In Banaskantha district in Gujarat, where rainfall is highly erratic and uneven, water availability may pose a limiting factor for agriculture in different ways. Extreme rainfall and flooding during the main growing season, monsoon, can devastate harvests overnight. In addition, farming is rendered impracticable when fields dry up in times of water scarcity during winter and summer (which complete the annual cycle of seasons).

Unreliability of natural water availability and economic development spurred Gujarat's pump revolution in the second half of the 20th century. At first, steady water availability and socio-economic development were tightly interlinked and the widespread enabling of intensive groundwater use through pumping led to an agrarian boom. This boom however, was followed by decline as aquifers diminished and now threaten the livelihood of millions of smallholder farmers (Shah 2009).

Holiyas[1] are relatively simple subsurface water storage systems for excessive rainfall and can be implemented without considerable technological knowledge and under comparatively little financial effort. The technique has been suggested to address the above mentioned water related socio-economic and environmental problems (Ashoka India 2010; UNFCCC 2014). However, no independent study on the actual performance of *holiyas* or *bhungroos* is available at present.

2. *HOLIYAS*

A typical *holiya* unit consists of a perforated pipe of which the top is confined by a square-shaped concrete pit with side lengths of about 3 feet (Figure 1). The pipe's diameter is typically about 4 inches while the depth ranges from 20 to 80 feet with around 30 feet being the most common depth. During times of heavy precipitation and resultant flooding in low-lying areas or ponds, these structures increase the infiltration rate of floodwater into the subsurface and thus mitigate the impact of floods on agriculture. The infiltrated water can be recovered at a later time when water scarcity is a pressing issue for farming (Figure 2).

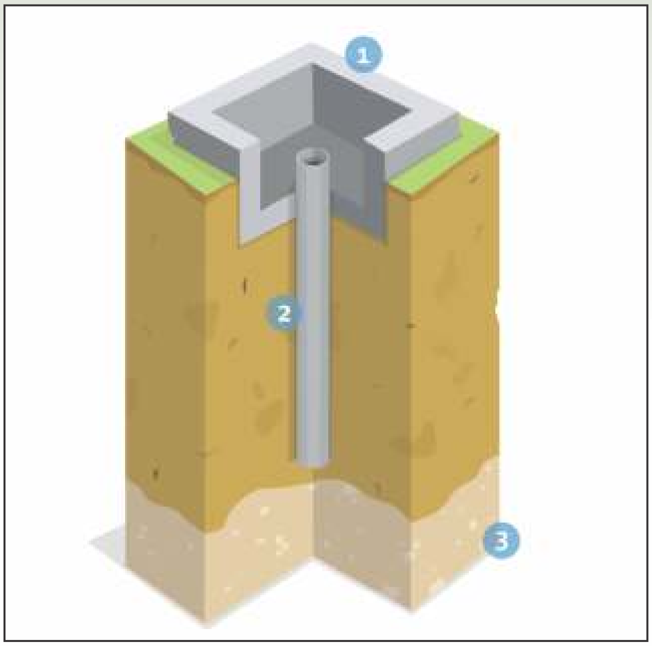

Figure 1: Schematic drawing of a *Holiya* / *bhungroo* unit as distributed by Motibhai Foundation and Lokvikas. The technical design may differ slightly from location to location. This image by UNFCCC (2014) has been modified from its original version by the authors of this report (1: concrete pit; 2: pipe with a perforated bottom end; 3: subsoil strata).

Ideally, *holiyas* are located at the lowest point of a field or capture area in order to facilitate as much inflow of excessive rainfall into the subsurface as possible. The bottom part of the pipe is perforated and water percolates through the pipe's holes into subsoil strata where it is stored in lenses. Only if the subsurface stratum or strata (intended for storage purposes) accommodate enough porous space and retain water in the *holiya's* vicinity, water can be recovered for use in times when water scarcity is a limiting factor for agriculture.

*This Highlight is based on research carried out under the IWMI-Tata Program (ITP) with additional support from the CGIAR Research Program on Water, Land and Ecosystems (WLE). It is not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or its funding partners.

[1]*Holiyas* is the Gujarati term used for pipe-assisted rainwater infiltration systems. An adaptation of *holiyas* that is well documented in literature and promoted by Lokvikas is *bhungroo*. In practice, the term *bhungroo* and *holiya* are used synonymously. This report will use the generic term *holiyas* for any structure that facilitates the infiltration of excessive rainwater into the subsurface of fields.

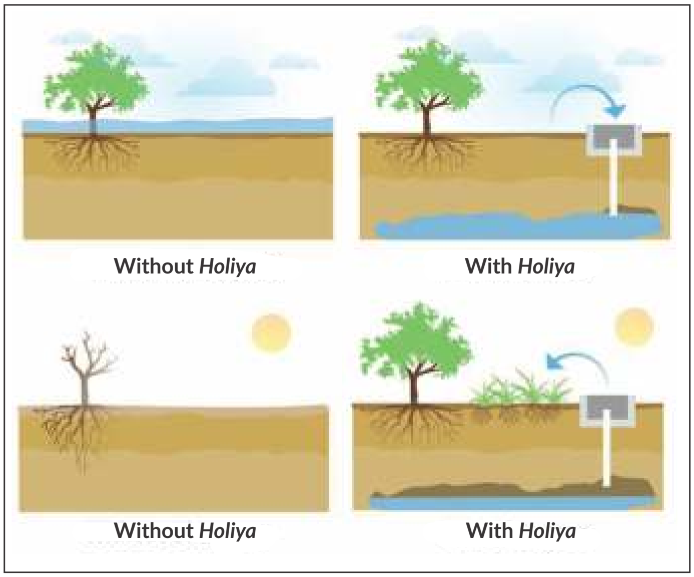

Figure 2: Theory of *holiya* functioning; Top: Excessive rainfall causes flooding of agricultural fields and devastates harvests. *Holiyas* facilitate the infiltration of rainwater into the ground and mitigate the impact of floods; Bottom: Infiltrated rainwater can be recovered during periods when water scarcity is a limiting factor for agriculture; This image by UNFCCC (2014) has been modified from its original version by the authors.

In theory, *holiyas* smoothen out the extremes of flood and drought for agribusinesses and possibly even decrease a farmer's dependency on other water sources such as canals and boreholes. The use of less borehole water would potentially decrease agricultural induced pressure on Gujarat's aquifers.

3. Objectives, Methodology and Limitations

The overall purpose of this study is to conduct an empirical analysis to address the knowledge gap regarding the performance of *holiyas* in Banaskantha district (Figure 3) and to establish preliminary knowledge about the socio-economic and environmental impacts of *holiyas*.

The assessment is based on a participative approach in which individuals and village communities were interviewed about the impact of *holiya* construction. In total, 41 farmers were surveyed using a questionnaire to collect qualitative data for descriptive research. A qualitative analysis was regarded an effective way of getting preliminary information about *holiya* performance because no independent knowledge about their actual performance is available. Responses on key questions, such as the impact of *holiyas* on flooding and agricultural output, were categorised for visualisation purposes.

Qualitative data is only as good and useful as the accuracy of the respondent's statements. This study is based on qualitative data which was provided by individuals and farming communities and assumes the accuracy of their statements and translations.

4. Results

Out of 41 surveyed people, 16 stated that their *holiya* was constructed by Motibhai R Chaudhary Foundation, 8 stated their *holiya* was constructed by Lokvikas (with Naireeta Services Pvt. Ltd. as technical agency) and 17 declared they had initiated the construction themselves which, in most instances, involved the hiring of a contractor.

4.1 Geo-hydrological and technical properties

The geo-hydrological properties of a specific location are among the main determining factors for the functioning of *holiyas*. Thirty respondents claimed that subsurface knowledge was available before construction. In many instances, respondents explained that experts were hired in order to conduct subsurface analysis while others had only little subsurface knowledge through ancestors or previous borehole drilling.

Geo-hydrological properties should also define a *holiya's* technical properties. However, *holiyas* are not always custom designed. Customisable features include its pipe and opening. The depths range from 20 to 80 feet with around 30 feet being the most common depth. On average, self-constructed *holiyas* are only around 25 feet deep. Most have a 4-inch wide pipe and roughly the bottom third of the pipe is perforated. Other customisable features include the pipe's opening which may be covered with a grid or protrudes from the ground in order to minimise influx of suspended solids or debris.

4.2 Construction, operations and maintenance

The actual construction cost and financial investment required for a *holiya* differs depending on whether it was constructed by the beneficiary or by an NGO. Motibhai Foundation covered 90 per cent of the costs and the beneficiary was expected to contribute about ₹ 1,000. This price is exclusive of a pump which costs about ₹ 25,000 to ₹ 30,000. Lokvikas' *bhungroos* cost the beneficiary ₹ 30,000 to ₹ 35,000 including a pump and beneficiaries have to cover around 80 per cent of the total costs. Self-constructed *holiyas* cost ₹ 2,500 to ₹ 5,000 without a pump. Operations and maintenance include costs associated with clogging, pump repair, energy cost etc.

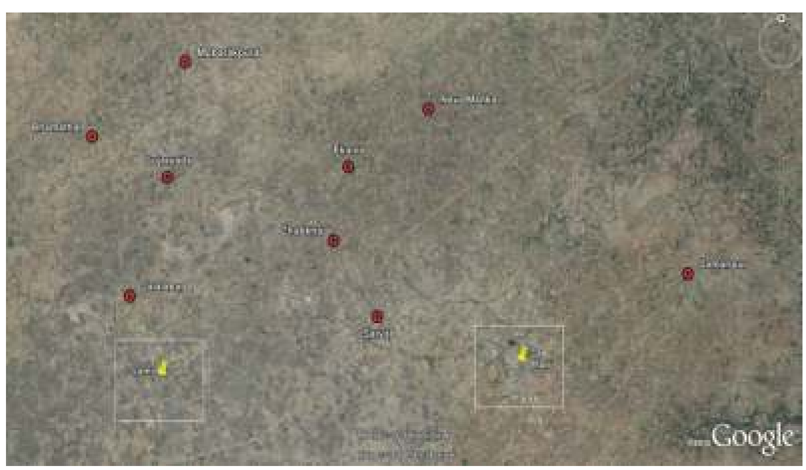

Figure 3: The study villages in Banaskantha district, Gujarat. Villages under consideration are marked with a red dot while noticeable cities are marked with a yellow pin

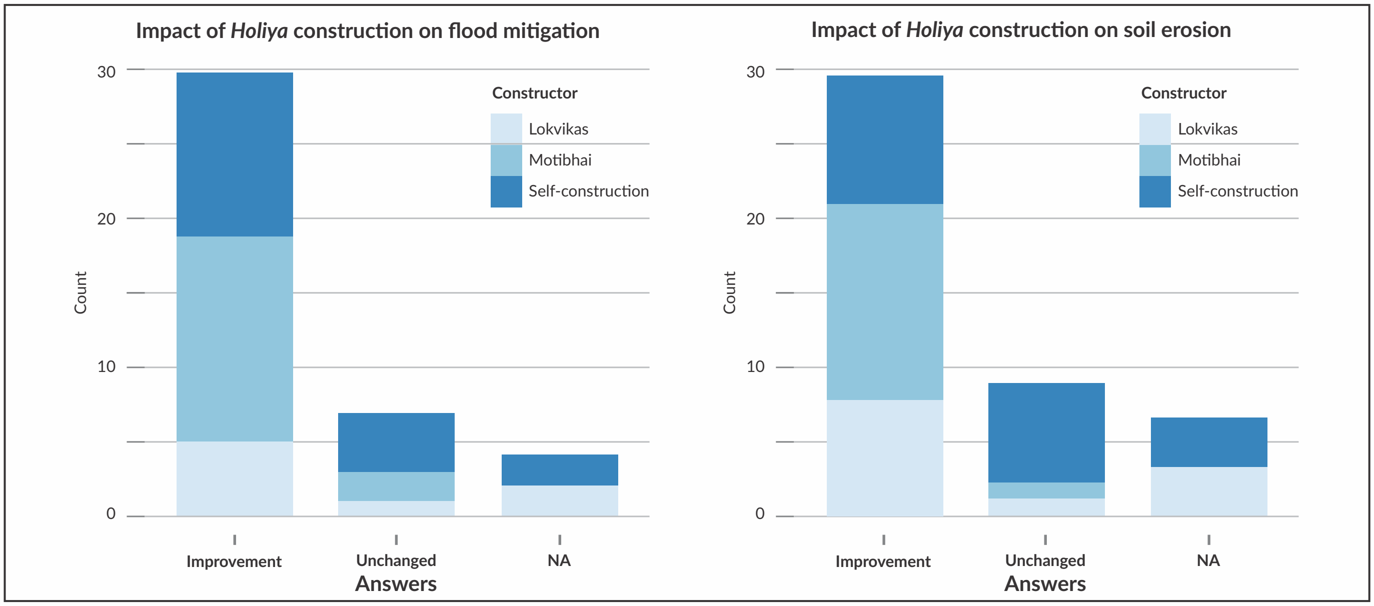

Figure 4: Qualitative assessment of the impact of *holiyas* on flood mitigation (LEFT) and soil erosion (RIGHT).

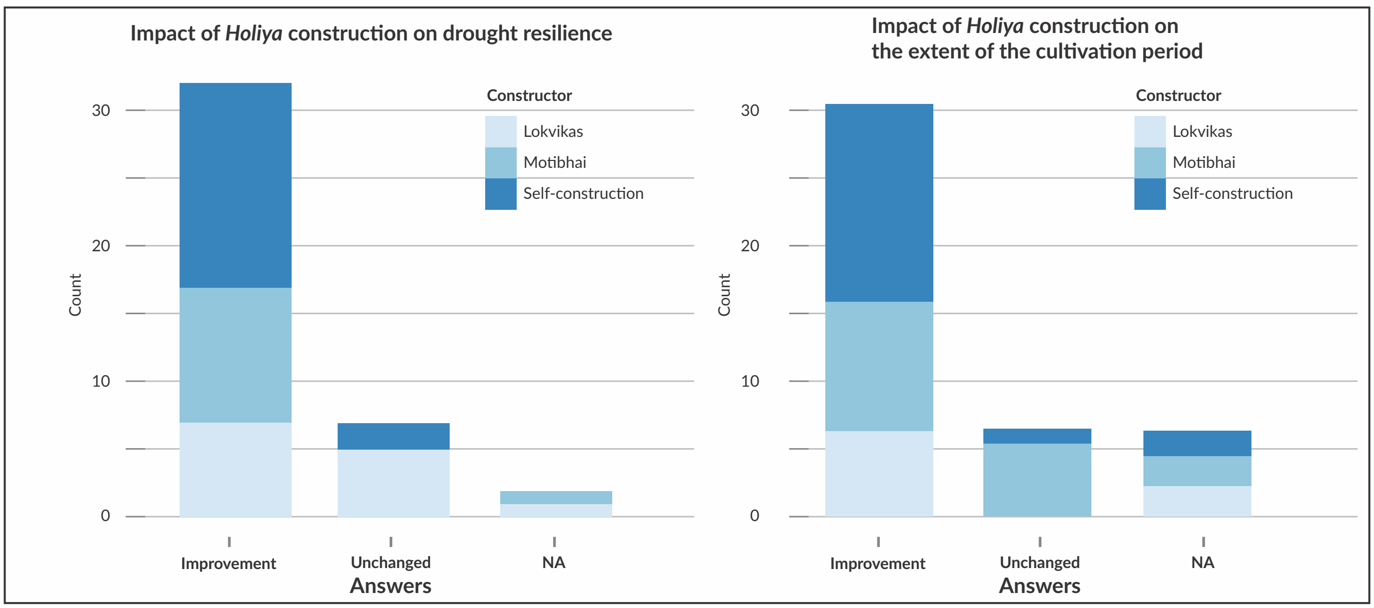

Figure 5: Qualitative assessment of the impact of *holiyas* on drought resilience (LEFT) and extent of cultivation period (RIGHT).

4.3 Flood mitigation and soil erosion

A clear trend emerged among respondents who mainly claimed an improvement in flood mitigation and soil erosion (Figure 4) as *holiyas* facilitate the infiltration of rainwater into the soil and thereby mitigate floods and side effects of floods such as soil erosion. The most common answer on how long it would take to clear fields from flooding was 7 to 10 days. Many respondents also pointed out limitations of *holiyas* in flood mitigation in case of extreme precipitation.

4.4 Water discharge capacity, water quality and alternative water sources

If *holiyas* successfully improve rainwater infiltration into the subsoil, water may possibly be recovered at a later time when water scarcity is a limiting factor for agriculture. As respondents were not expected to be able to provide metrics for *holiya* discharge they were instead asked if the construction had an impact on farming with respect to drought resilience or the extent of the cultivation period.

Both aspects were perceived to have improved by the majority of respondents (Figure 5). *Holiyas* enabled some farmers to grow crops also during winter and (in some instances) green fodder for livestock during summer. Water quality is adequate for agriculture but deteriorates after abstraction of large quantities of groundwater. Alternative water sources are mainly canals and boreholes and are likely to be used in addition to *holiya* water if financially affordable.

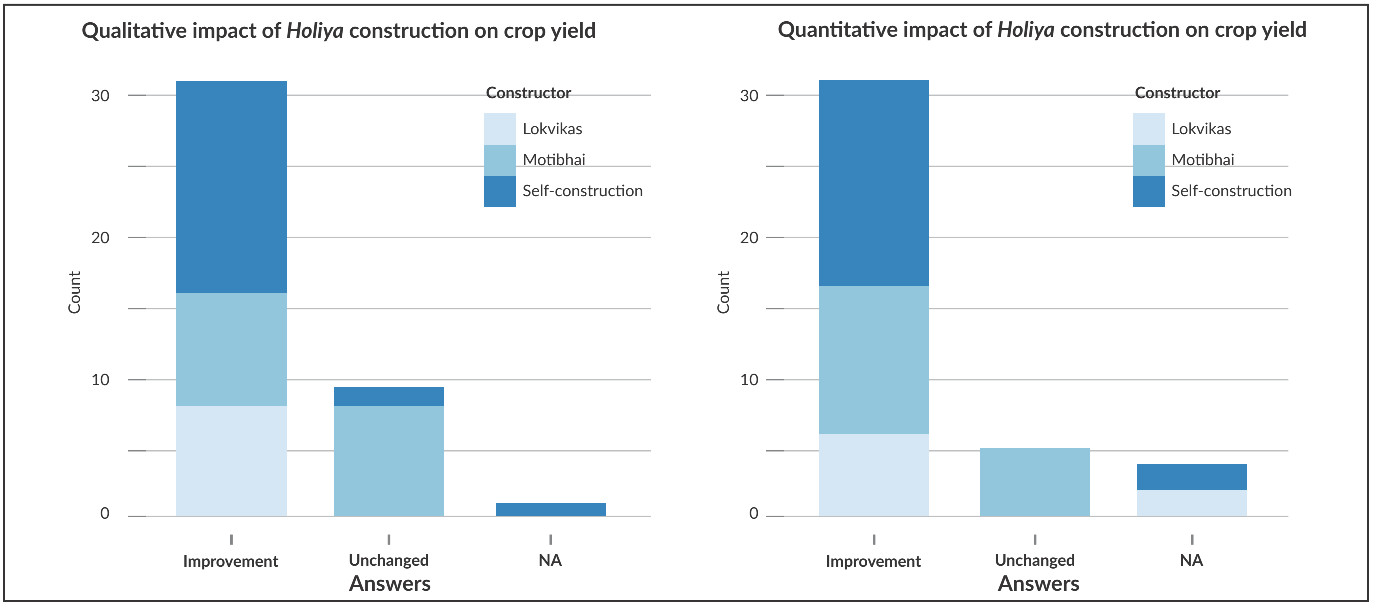

Figure 6: Qualitative assessment of the impact of *holiyas* on crop choices (LEFT) and crop yield (RIGHT).

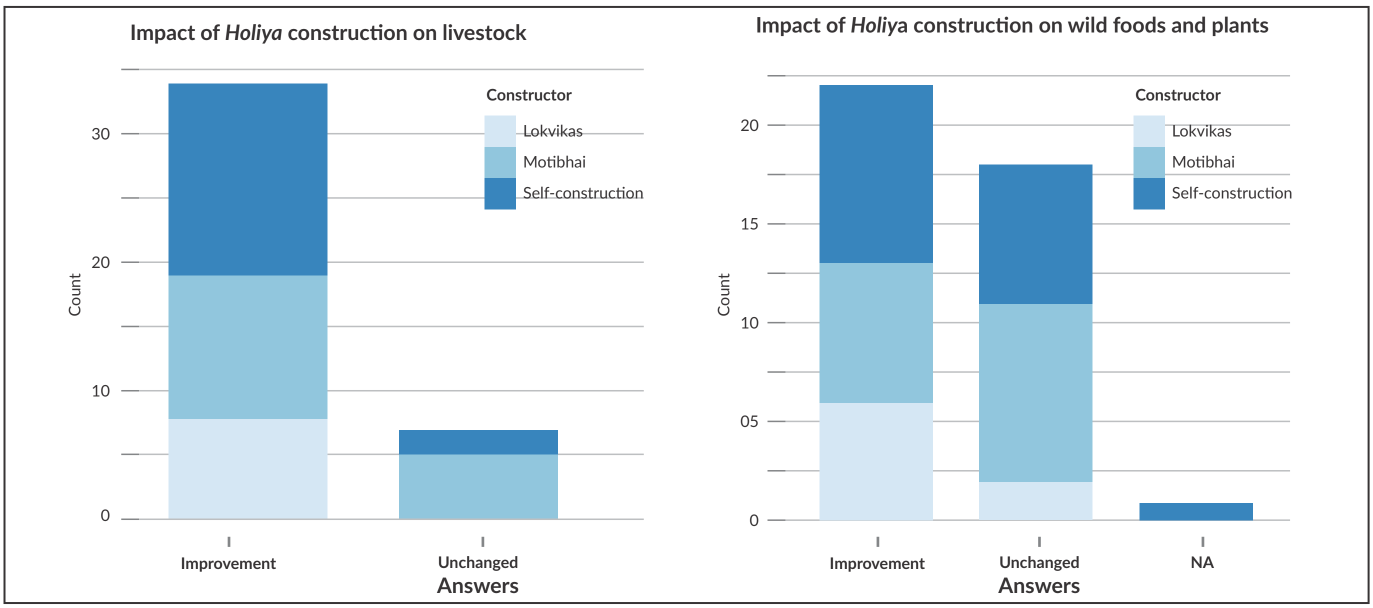

Figure 7: Qualitative assessment of the impact of *holiyas* on livestock (LEFT) and wild foods and plants (RIGHT).

4.5 Impact on agricultural output

Increased drought and flood resilience and an extended growing season should result in an improvement in agricultural output. Only a few respondents were able to put metrics behind the increase in crop yield which they stated to be around 20 to 25 per cent. An improvement was not only observed in quantity but also in quality as more desirable crops could be grown (Figure 6). Crops grown after *holiya* construction included cumin, pioneer grass, cotton, castor beans, wheat, pearl millet and mustard. An increased agricultural output also increases the feedstock which is available for livestock. Wild foods and plants seem to be less affected in their availability (Figure 7).

4.6 Socio-economic impact

For individuals who depend on agribusiness for their livelihood, a qualitative and quantitative improvement of agricultural output should also impact their socio-economic well-being. Families are less prone to natural fluctuations in water availability which has direct implications for livelihood resilience as incomes are more stable and consistent. Money can be channelled back into farming improvements, housing or education. Lokvikas pursued women empowerment through a distribution concept in which women are assigned to be the owners of *holiyas*. Our assessment was not designed to generate evidence to ascertain the success of this concept.

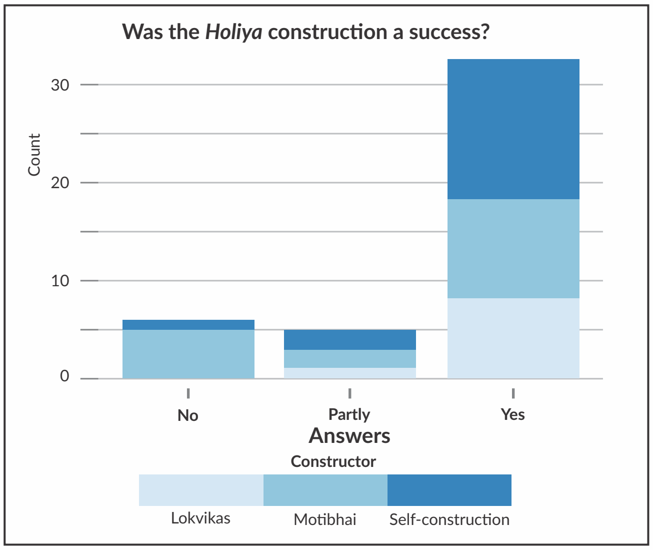

Figure 8: Qualitative assessment of the success of *holiyas*

4.7 Environmental impact

Holiya water is a locally available, renewable and therefore environmentally benign water source with a lower environmental impact compared to alternative water sources: canal and borehole. However, in only four instances, the surveyed individuals stated that they use *holiya* water instead of the water sources on which they relied earlier (canals and boreholes). For people who are financially able to continue using conventional water sources such as canals and boreholes, their continuing usage is likely to be the case. Accordingly, the impact of *holiya* construction on reduction in water abstraction from alternate sources appears to be rather limited.

4.8 Success

When surveyed individuals were asked whether *holiya* construction was a success, most respondents replied with "yes" (Figure 8). It should be noted that this question is rather unspecific and possibly only implies that farmers regard some aspects of *holiya* construction to be a success. The results do not suggest that every potential benefit of *holiya* implementation materialised.

No type of *holiya* (self-constructed, Motibhai, Lokvikas) was identified to perform better than others. The sample size is relatively small and results about performance should be considered with caution. The authors of this report also question the impartiality of some Lokvikas beneficiaries and don't rule out bias towards self-constructed *holiyas*.

5. Discussion

The most important finding is that the majority of respondents perceive to have benefited from the construction of a *holiya*. However, this assessment is based on qualitative data and the extent to which *holiyas* are beneficial is subject to variations which were not quantified by this report. Answering with "yes" on whether the construction of a *holiya* was a success does not mean that every potential benefit of a *holiya* has materialised for a respondent. It only allows the conclusion that the responding individual has perceived the *holiya* to be successful *in some way*. Nevertheless, in many instances *holiyas* appear to hold the potential to mitigate the impact of extreme occurrences of water abundance and/or scarcity at least to a certain extent and thereby enable an extended cultivation period compared to before. Subsequent increase in agricultural output possibly improves the socio-economic wellbeing of individuals.

The success of *holiyas* also depends on external factors such as the availability and cost of other water sources. This became evident when respondents explained they were disincentivized to use and maintain their *holiya* because canal water became available at cheaper costs compared to *holiya* water. Even if alternatives such as borehole water or canal water are more economically viable, it should be noted that their environmental costs are likely to be much higher. *Holiyas* utilise rainwater and are thus based on a renewable and locally available water source. In contrast, canal water requires huge infrastructural efforts and potentially only shifts the burden of water stress on ecosystems towards different locations while borehole water is infamous for contributing to aquifer depletion in Gujarat (Shah 2009).

Hence, it was considered that *holiya* water may hold the potential to be an environmentally benign alternative for canals and boreholes if they function well. Some respondents recommended construction or distribution of deeper and wider pipes in order to improve performance. Others suggested combining *holiyas* with advanced irrigation technologies such as drip irrigation which is actually not an improvement of the *holiya* technology itself. Additional leverage points may include extended geo-hydrological testing before *holiya* construction and the implementation of more customised designs or an increase of water infiltration into *holiyas* through check dams and water conveyance structures.

However, the question why *holiya* construction did not spread to more villages and larger areas even though they were perceived by adopters as being successful, after they were first being built in the mid 1990's, remains. The data suggest that an upsurge in self-constructed *holiyas* only arose after NGOs started to distribute them in 2005. Some respondents claimed that mainly economic factors would pose a burden for constructing a *holiya*. This claim was not independently verified.

6. Conclusion

It is believed that this study is the first to independently assess the socio-economic and environmental impact of *holiyas* on smallholder farmers in Banaskantha district in Gujarat. The findings may be limited as no metrics are provided on the performance of *holiyas*; neither with regard to socio-economic advances nor their environmental impact. Nevertheless, some major trends emerge from statements issued by respondents and their perception of *holiya* performance.

Credit: Rahul Rathod

Water abstraction from a *holiya* in Chabkha village, Banaskantha

Most *holiyas* are considered to be a success with regard to flood mitigation, soil erosion, drought resilience, extent of the cultivation period, crop yield and/or livestock. No potential to decrease agricultural induced pressure on aquifers was found at this current time. In general, no negative aspects seem to accompany the construction of *holiyas* (other than possibly investment costs) and *holiyas* could perhaps be conceived as a *no regret measure*.

However, as so often when immersing into a new field of study, more questions emerge than being solved. The following points may provide starting points for future research focuses:

- Quantitative data could establish a more confident link between the perceived socio-economic benefits by respondents and the construction of *holiyas*. Further investigations should rule out that other factors are causative or concurrently causative for the respondent's perception of socio-economic advances.
- How can *holiya* performance be improved with respect to geo-hydrological knowledge and technical features?
- What are the exact factors determining the success of a *holiya* with regard to socio-economic benefits?
- What has prevented dissemination and adoption of self-constructed *holiyas* after they were first constructed in the mid 1990's? What are current trends of dissemination? What are drivers and barriers? If desirable, how can dissemination be facilitated? Ekalva village was home to many self-constructed *holiyas* and could be a good starting point for field research on this subject.
- How can beneficiaries be disincentivized from using canal and borehole water? Do *holiyas* hold the potential to decrease agricultural induced pressure on aquifers?

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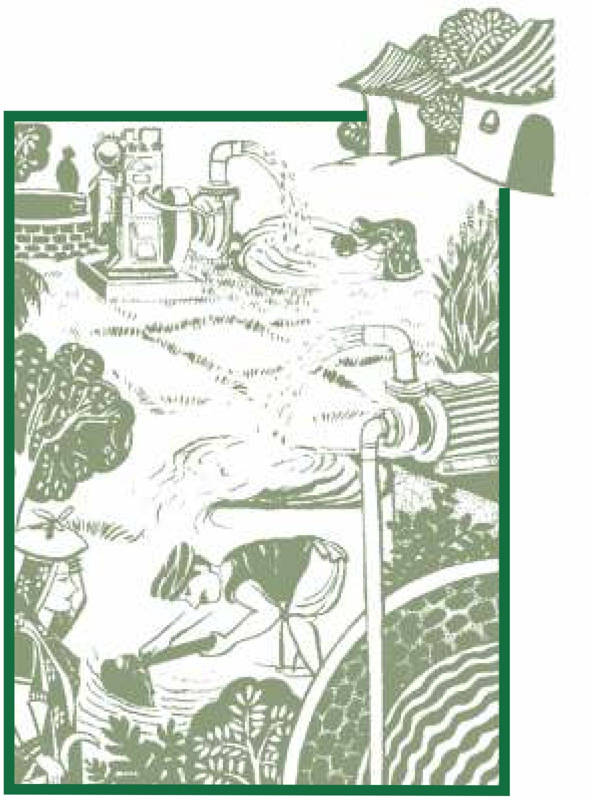

About the IWMI-Tata Program and Water Policy Highlights

The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations. Through this program, IWMI collaborates with a range of partners across India to identify, analyze and document relevant water management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

Water Policy Highlights are pre-publication discussion papers developed primarily as the basis for discussion during ITP's Annual Partners' Meet. The research underlying these Highlights was funded with support from International Water Management Institute (IWMI), Tata Trusts, CGIAR Research Program on Water, Land and Ecosystems (WLE) and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or any of its funding partners.

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