SESSIONE POSTER

PARTICIPATORY DESIGN OF ROOFTOP WATER HARVESTING SYSTEMS FOR SMALLHOLDER FARMERS' IN THE CORRIDOR SECO REGION, GUATEMALA

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Sommario

La Regione del Corridor Seco, Guatemala è da sempre soggetta a crisi alimetari, aggravate da climate change, degradazione del suolo e scarsità idrica. L'adozione di sistemi di raccolta di acqua piovana da tetto rappresenta una fonte di accesso fondamentale alla risorsa idrica, specialmente nelle comunità rurali. Il presente lavoro propone un approccio di progettazione partecipata per il miglioramento di tali tecnologie nel dipartimento di Camotán, sulla base del quale sono state realizzate 23 nuove installazioni. I risultati del progetto mostrano che tutti i nuovi sistemi sono funzionanti e che la raccolta dell'acqua piovana contribuisce alla food security delle comunità coinvolte.

Abstract

The region of Corridor Seco, Guatemala, is facing a severe food crisis caused by extreme weather events, land degradation phenomena and water scarcity. In this situation, the adoption of Rooftop Water Harvesting systems can effectively support local livelihoods, especially in marginalised communities. We present a Participatory Design approach, realised with local population, to improve water harvesting systems damaged in the last 3 years. Taking advantage of local materials and construction style, "Soberanos" project managed to realise 23 new cisterns, all functioning after the first rainy season. Extended results showed how water harvesting can effectively increase food security in the region.

Keywords

Water Scarcity, Participation, Diagnostic Analysis, Adobe bricks, Clay plaster

Introduction

Water Harvesting (WH) is worldwide recognized as an effective mean to deal with water scarcity (Rockstrom & Falkenmark, 2015). It allows the collection and storage of rainwater, floodwater or quick runoff and their conversion to productive uses, ensuring water availability for domestic and agricultural use, enabling a lower exploitation of the aquifer, preventing erosion events and providing significant ecosystem services.

Among all existent techniques, Rooftop Water Harvesting (RWH) plays a crucial role, since it is one of the most common alternative sources of water for domestic consumption, to such an extent that it is almost the only source of water supply in many arid areas of the world (Bailey, et al., 2017). RWH is a low-tech, simple and affordable tool that can be easily conformed both to urban and rural areas (Worm &van Hattum, 2006), significantly increasing the adaptability of smallholder farming systems to extreme weather events and to climate changes, by providing a more stable access to water resources.

The region of Corridor Seco, situated in the south-eastern part of Guatemala, is characterized by erratic and unreliable rains that, joined to extreme events and a low annual rainfall amount caused a drastic condition of food and water scarcity in last twenty years. In 2001, a 40-day drought destroyed corn and bean crops in the municipalities of Camotán, Olopa and Jocotán, officially causing 48 deaths. Furthermore, in 2017 between 120,000 and 400,000 families suffered of the risk of famine and drought (Wirtz, 2017). Thus, in such context, RWH can successfully represent a vital strategy to cope with water scarcity.

To face this increasingly critical situation, in 2013, the project "Accesso alla risorsa idrica con tecniche appropriate e sostenibili nelle comunità rurali guatemalteche del Municipio de Jocotán del Guatemala per garantire la sovranità alimentare e combattere la denutrizione infantile" – "Improving water access with appropriate and sustainable techniques in the Guatemalan rural communities of the Municipio de Jocotán of Guatemala to guarantee food sovereignty and combat child malnutrition", funded by Water Right Foundation and implemented by AUCS NGO, Mani Tese NGO ONLUS and GESAAF Department of University of Florence, realised the installation of 34 household RWH systems in the municipality of Camotán. These structures, composed by a rooftop collection system connected with an underground tank, were realized to meet the needs of rural families whose only source of water supply consists of few, overexploited, springs. The project had the multiple objective of improving access to food and nutrition through production diversification as well as through the sensitization of local population.

The rooftops systems realized are composed by a catchment surface constituted by iron sheet roofs and by a delivery system consisting of gutters, conveying water to underground storage reservoirs. Rainwater is then employed to irrigate family gardens using EMAS pumps, an appropriate technology realized with materials available on site, already proven to be effective in areas where human progress is considerably constrained by water scarcity (Bresci et al., 2013).

The project provided good results for what concerns the acquisition of consciousness of the benefits provided by a varied and balanced diet and the awareness of the role played by family horticulture, not only for self-sustenance, but also as a mean for land re-appropriation to cope with large-scale agro-business activities.

Between 2014 and 2016, from the communications with the project responsible in Guatemala, it emerged that the upscaling of the project, represented by the realisation of around 100 new cisterns, brought inadequate results (Personal communication, November 2016), mainly due to problems related to the internal plastic coating of the cisterns.

In May 2017, “Soberanos” project, funded by the Tuscany Regional Government and implemented by Mani Tese Ong Onlus, GESAAF Department of the University of Florence and Association Santiago de Jocotán, allowed the identification of the main functioning-related problems, identified by field surveys, focus groups and interviews. Moreover, the use of Participatory Design methodology (Spinuzzi, 2005)allowed to deal with the problems that were emerged and to realize an implemented underground tank. The proposed improvements were then adopted to construct 23 new cisterns.

The present works describes the participatory process realised for the analysis of old cisterns failure and the design of a new prototype, presenting the main innovations developed, and the assessment of the status of the cisterns after the first rainy season. Insights and spaces for future research and projects are then discussed.

Materials and Methods

Study Area

The analysis was carried out in three villages in the municipality of Camotán - district of Chiquimula (Fig.1): Lantiquin (720 m a.s.l.), Dos Quebradas (1040 m a.s.l.) and Rodeo (990 m a.s.l.). Weather data are available for Camotán (between 3 and 8 km away). The average annual temperature is 25.4°C, the minimum annual 17.9°C and the maximum 33.9°C. The annual precipitation is 940 mm with an amount of 874 mm during the wet season and 66 mm during the dry season. The innovative system was applied for 13 cisterns in Lantiquin and for 10 cisterns in Dos Quebradas, involving 35 local households. Study area shows prolonged dry spells, for which it is necessary to collect and store rainwater in the wet season for cultivations and food self-production during dry periods.

Figure 1 – Localisation of Chiquimula district - Guatemala

Participatory Analysis and Participatory Design

The research work has been conducted during a field work of 2 weeks in the area of study, involving the communities of Rodeo, Dos Quebradas and Lantinquin, where the damaged cisterns are present. In each community, a focus group discussion was held. 6 field visits were realised to analyse the failure occurred to the cisterns realised after 2013, and for each visit, a questionnaire was realised to the cistern’s owner. In addition, a SWOT analysis was realised for Rodeo community, localised in the most remote and arid area of the municipalities involved in the project (Fig.1).

Figure 2 – Participatory activities carried out during the field work, May 2017, Rodeo community. Left: focus group discussion; right: Reporting of the SWOT analysis during the meeting.

The methodology of Participatory Design (Spinuzzi, 2005) was utilised to design an improved prototype of cistern, to be used for the implementation of "Soberanos" project. The methodology has originally been conceived for designing work organisation routines in Northern Europe, but it was also applied in development projects (Cole et al., 2014; Zewge et al., 2015).

The methodology is composed by three main phases:

1) *Initial exploration of work:* it involved the detailed analysis of the technology use on site, with the aim of familiarising with the context and the workflows used in the main duties. At the level of the present work, phase one was realised by the field visit to the structures and visits within the communities.

2) *Discovery process:* users and designers clarify the users' goal and agree on the desired outcome of the process. To elaborate this phase, the project group draft from both the results of phase 1, and from the SWOT analysis realised.

3) *Prototyping:* users and designers engage an iterative process to shape technological artefacts to fit with the needs expressed in Phase 2. In the framework of the project, this part was realised by designing a prototype of a new cistern and to refine the design through a pilot installation realised in Lantinquin community.

An analysis of the condition of the 23 cisterns built with the new design style has been carried out in January 2018.

Results and Discussion

The participatory analysis showed that problems were primarily linked to the degradation of the internal plastic coating, in polyethylene mesh.

SWOT analysis (Tab.1) showed that the main problems were linked to the degradation of both pumping and water storage system. The main causes of the failure of the systems were the damages to the plastic coating, given by rodents' attacks, and by the irregular terrain under the coating, that generated breakages under the pressure of the water stored.

Additional problems were caused by the presence of insects and snakes within the cistern. To cope with these issues, in the initial phase the improvement of cisterns with concrete, or a circular design style was proposed. When analysing possible threats to this strategy, concrete was judged too expensive, while circular design too complicated to be implemented at field level, given the low possibilities to operate within marginal localities in the Corridor Seco. A more elaborated participatory design approach was then engaged.

Strengths	Weaknesses	Opportunities	Threats
- Reduction of malnutrition - Increase of seed production - Possibility of selling vegetables cultivated through reservoir water - Possibility of drinking reservoir water	- Damaging of the plastic coating (due to irregular terrain, rodents attack) - Snakes and insects access the cistern -Damages at the wooden support of EMAS pumps	- Improvement of reservoirs with concrete - Circular reservoir design	- Concrete is expensive - Circular reservoir are difficult to build

Table 1 – Results of the SWOT analysis realised in Dos Quebradas municipality.

SWOT analysis, however, highlighted the positive outcomes of previous programs, including the reduction of malnutrition, the increase of seed production, and the availability of water for domestic use and horticultural production, that allowed local communities to generate income by selling vegetables. Thus, it can be affirmed that, once solved the cisterns' problems, the project approach can effectively increase food security in the region.

Participatory Design

The participatory analysis, together with the site visits at the damaged cisterns (Fig.3), allowed to carry out the "Initial exploration of work" phase. In the "Discovery process" phase, the community of the Soberanos project, namely the designers (experts from GESAAF department and Asociación Santiago Jocotán) and the users (the people from Dos Quebradas and Lantinquin), defined the main outcome of the process, namely the building of more resistant cisterns, with a regular edge (to be closed against intrusion of rodents, snakes and insects).Based on the previous phases, a prototype of improved underground tank was developed and realised in the "Prototyping phase" (Fig.4), to deal with emerged problems.

Figure 3 – Old cisterns. Left: construction in 2014. Right damaged cistern in 2017

A pyramid trunk shaped excavation was realized with base dimensions of 2.7 x 2 m and a depth of 0.50 m. To increase the volume of the cistern and to have a uniform edge for the cistern closing, with another polyethylene mesh, the maximum level was raised by constructing an adobe wall along the edges of the excavation. Adobe were realized by families in loco, using local clay and straw. The excavation was then plastered with clay and coated with a polyethylene sheet. The choice of adobe and clay coating instead of the initially requested cement one permitted to avoid rodent related problems with a more sustainable and environmentally appropriate approach, also making it possible to use local materials.

These solutions were suggested by local participants and adopted at design and implementation phase thanks to the participatory framework. Moreover, a workshop on the construction and maintenance of EMAS pumps was carried out in Dos Quebradas community, enabling people not only to construct pumps, but also to correctly operate and maintain them.

The analysis of project development stage, carried out in January 2018 showed that, since May 2017, 23 improved cisterns were realized in two communities: 13 in Lantinquin and 10 in Dos Quebradas. After the rainy season, all the cisterns are functioning, and they are used not only for irrigation of family gardens, but also for domestic use, thus providing an alternative source of water supply and an effective mean to deal with water scarcity.

Figure 4 – New cistern prototype. Left: no plastic coating, right, with coating (Photos: May 2017).

Apart from the technical realisation, within the "Discovery process" it was also highlighted that a regular monitoring of cisterns by the implementing NGO or institutions is needed. Thus, the project team recommended the adoption of a dedicated budget line for financing monitoring activities, when new project proposals will be written.

Regular monitoring is foreseen also for evaluating the overall effect of RWH in the region. Quality monitoring is needed to evaluate whether is safe to continue drinking cisterns water. In addition, further analysis is needed to assess how many cisterns will be working after the second rainy season. Finally, a cost-benefit analysis is needed to assess if the intervention is financially sustainable and how much it can positively impact horticultural crop yields and thus farmers' income, considering also that this topic represents a research gap at academic level (Rahman, 2017).

Conclusions

The present work was carried out in the framework of "Soberanos" project, funded by Tuscany Regional Government, Italy, to improve the rooftop water harvesting systems in the Region of Corridor Seco, Guatemala. An analysis of systems built between 2014 and 2016 showed how these systems failed, due to damages to the polyethylene plastic mesh used for reservoir coating, caused by the irregular soil shape and by the intrusion of rodents. A Participatory Design approach allowed to design an improved cistern in May 2017, considering farmers' expertise and localmaterials, in particular the use of adobe bricks to enlarge cisterns and have a better sealing, and the use of clay plaster over soil for having a regular surface for the polyethylene mesh settling. In autumn 2017, 23 new cisterns were realised, and all of them are working after the first rainy season. Results also showed how the interventions of 2014, apart from structures' failure, increased the food security of local farmers. Further analysis should focus on a long-term monitoring, including water quantity, quality and agricultural production, considering also the cost-benefit analysis of the intervention.

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