Community-based rehabilitation of mountain terraces in Cyprus

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ABSTRACT

Participatory methods and community-based approaches have an important role to play in combating land degradation. This paper follows a well-defined participatory framework to identify key stakeholders and to select Sustainable Land Management approaches for reducing soil erosion and land degradation in the Troodos Mountains of Cyprus. Among the options suggested and evaluated, terrace rehabilitation had the best overall performance, followed by crop diversification and afforestation. Stakeholders agreed that the rehabilitation of dry-stone terraces was the preferred option, as it is a practice with high environmental benefits and fits well in the local socio-cultural context, despite the higher cost compared to other options. In the first year of implementing the approach, three mountain communities co-organised hands-on terrace maintenance events, engaging more than 160 people in rehabilitation activities. The community-based approach has sparked the interest of people within and beyond the research site, and another series of events is scheduled for the coming season. This outcome indicates that social innovations can benefit from the integration of local and scientific knowledge, while participatory process can enhance the self-confidence and organisational structures of local communities. Sustaining and enhancing the impact of the approach in the long-run requires developing local terrace maintenance institutions, actively engaging the youth in terrace management and improving the profitability of mountain farming through the differentiation of local products.

Keywords: participatory action research, Mediterranean mountains, dry-stone terraces, sustainable land management, soil erosion

INTRODUCTION

The construction of dry-stone walls is a millennium-long process of establishing complex systems to manage slope dynamics (Tarolli *et al*., 2014; Agnoletti *et al*., 2015). Considering the relative scarcity of suitable land for farming in mountain regions, dry-stone terraces provide an intensive cultivation form which requires little mechanical aid but high input in terms of labour (Rolé, 2007). The obvious purpose of agricultural terraces is food production, although their relevance to modern concerns relates these man-made structures to sustainable land management (SLM), water retention and control of soil erosion in sloping hillsides, as well as being a biodiversity habitat (Agnoletti *et al*., 2015). Due to their important multi-functional uses and their long existence over many human generations, terraced landscapes are a well-regarded form of *landesque capital* (Widgren, 2007) and are considered imperative cultural landscapes (Torquati *et al*., 2015).

The importance of agricultural terrace systems has been widely recognised in recent years, which has led to the proliferation of protective actions at the European level. For instance, to increase the competitiveness and to sustain the ecological functions of landscape features such as dry-stone terraces, the European Commission (2009; 2013) provides subsidy support to farmers for their conservation, restoration and maintenance. Furthermore, the agronomic, historic and biocultural value and diversity provided by traditional landscapes has been also recognised by UNESCO's (2014) Florence Declaration.

Despite their importance in terms of ecological provision and cultural heritage, and the financial support for their preservation, mountain terrace landscapes in the

Mediterranean region are gradually abandoned as a result of socio-economic changes and radical Common Agricultural Policy reforms (Koulouri & Giourga, 2007). The economic significance of Mediterranean mountain farming has been drastically diminished over time mainly due to high production costs, low response to market demands and limited development opportunities. Consequently, mountains have become marginal territories with few inhabitants due to population migration to urban centres (Lasanta *et al*., 2001). Abandonment of terraced agricultural systems introduces geomorphic processes such as soil erosion and slope failures (Camera *et al*., 2014) and represents considerable sediment sources in semi-arid environments, as reported by Lesschen *et al*. (2008) in Spain and Djuma *et al*. (2016) in Cyprus. Soil erosion is one of the major threats to soils in the Mediterranean (Panagos *et al.,* 2015). In mountain regions, soil erosion infers drastic reduction in soil productivity and exposure of bedrock, which could eventually result in desertification (Vieira *et al*., 2015; Xie *et al*., 2015). In addition to land degradation, terrace abandonment implies detachment of the young generation from traditional agronomic practices and loss of indigenous knowledge (Tarolli *et al*., 2014).

Terrace abandonment in Southern Europe and the associated erosion risks have been increasingly reported in the literature (Arnáez *et al*., 2015). According to the review study of García-Ruiz & Lana-Renault (2011), narrow bench terraces that were impossible to work with machinery have been gradually abandoned since the 1950s. These authors indicate that the evolution of land following abandonment depends on the time of abandonment, the climatic conditions, the field characteristics and the management regime, and highlight the need of targeted policies capable to remediate the consequences of soil degradation. Tarolli *et al*. (2014) also provide a review of the critical issues

associated with land abandonment and explore the potentials of structural (e.g. identification of failure mechanisms and maintenance of collapsed walls) and non-structural measures (e.g. awareness campaigns, international initiatives and training of young people to maintain terraced landscapes) for the management of such environments.

There is a growing recognition that participatory methods and community-based approaches have an important role to play in combating land degradation, as technocratic and top-down approaches have often led to implementation failures or low acceptance by land users (Ludwig, 2001). Given the complexity, diversity and dynamics entailed in soil degradation issues, the need to engage multiple stakeholder groups, and especially local stakeholders and land users, is nowadays widely accepted as the way forward (Warner, 2005). According to Berkes (2004: 628), "*to ground conservation effort, we need a more nuanced understanding of the nature of people, communities, institutions, and their interrelations at various levels*". Schneider *et al*. (2009) note that the quest for sustainable soil protection should be conceived as a process of knowledge creation and co-production between farmers, experts and scientists.

In essence, a key objective of participatory research processes is to foster knowledge exchange and mutual learning among different stakeholders (Vila Subirós *et al*., 2015; Pereira *et al*., 2016), that can potentially lead to the development of innovative, sustainable and broadly accepted solutions (Schwilch *et al*., 2009; Giger *et al*., 2015) Knowledge of different stakeholder groups is often highly disconnected. Thus, achieving an effective interdisciplinary research foundation requires understanding of the main issues in the area of interest and identifying relevant stakeholders from the early stages of the process (Reed et al., 2009). This highlights the usefulness of developing multi-

stakeholder platforms, which can function as decision-making bodies and enable an empowered and active engagement of interdependent stakeholders in the search for solution-oriented SLM options to a common problem (Steins & Edwards, 1999; Faysse, 2006). There is also a need to shift from conceptual frameworks to dynamic knowledge-action interfaces, to implement SLM practices that benefit local societies and to provide feedback to policy makers (Wolfgramm *et al*., 2015). Interestingly, participatory methodologies and community-based approaches have been formulated and mainly applied in the context of developing countries (e.g. Yuliani *et al*., 2015; Beyene, 2015; Blaikie, 2006), and as such there is much less documentation in the European context.

The aim of the presented action research is to identify and test a SLM option for reducing soil erosion and land degradation in terraced mountain environments. A community-based approach has been developed with three communities in the Troodos Mountains of Cyprus. The paper describes the interdisciplinary process and the lessons learned from the integration of local and scientific knowledge to combat land degradation, and discusses the implications and outlook of the approach.

METHODOLOGY

Research site

The Troodos Ophiolite Complex on the island of Cyprus covers an area of 2332 km^2 (i.e. 40% of the area under the effective control of the Republic of Cyprus) with 31% mean slope gradient; it consists of 140 communities with a population of around 50,000 inhabitants. Abandonment of agriculture, practiced on terraces, is pervasive; 20% of the agricultural land of the communities above 600 m has been abandoned in the past two

decades (CyStat, 2014). The research site in this paper refers to the area comprised by the communities of Polystypos, Alona and Platanistasa, located along the northern slopes of the Troodos Mountains (Figure 1). These communities are representative of the agricultural practices and land use trends in the region.

Agriculture is practiced on dry-stone terraces with narrow (1-3 m) to medium-base (3-6 m) bench, constructed by cutting and filling in slopes with gradient between 20-40%. The main crop grown on terraces is wine grapes, followed by almond and deciduous fruit trees. The population of the three communities has decreased by 73% over the past 30 years; from 1,142 inhabitants in 1982 to 312 in 2011 (CyStat, 2012). The depopulation of mountain communities along with high farming costs constitute the main constraining factors for soil conservation. Consequently, many mountain terraces have been abandoned and dry-stone walls remain unmaintained, sometimes causing a domino effect of collapsing terraces (Figure 2). In some locations, nature is taking over and the degradation of dry-stone walls and soil erosion is more gradual than on the poorly vegetated terraces. In addition, the semi-arid climate and the high summer temperatures imply high fire risks and increase the susceptibility of the area to further land degradation and potential desertification.

Participatory Process

The participatory process developed by the EU RECARE research project was broadly followed and consists of four main steps (Caspari *et al.*, 2014; 2015): (i) establishment of a stakeholder platform, (ii) identification of SLM options to combat land degradation and soil erosion in the research site, (iii) assessment of SLM options using the World Overview of Conservation Approaches and Technologies (WOCAT)

questionnaires (www.wocat.net), and (iv) selection of a SLM option for implementation using a Multi Objective Decision Support System.

Stakeholder Platform

The stakeholder platform is the principal component of the participatory process and consists of two components: a network of stakeholders and the tools utilised to interact, communicate and promote the co-production of knowledge with stakeholders (e.g. formal and informal meetings, stakeholder workshops, field visits, focus group discussions, dissemination material etc.).

Stakeholder identification and analysis was based on the methodological framework developed by Leventon *et al*. (2016), which provides a systematic and practical approach to identify and engage relevant stakeholders in transdisciplinary research. In particular, the framework was based on a structured snowball sampling method using a two-part questionnaire: (i) the first part focused on stakeholder characterisation (e.g. by activity, sector, role, and interest) and on collecting information on the administrative structures and the nature of soil degradation in the area; (ii) the second part prompted the identification of existing forums for stakeholder communication and collaboration (such that the subsequent participatory steps are planned to complement rather than distract existing processes), while responders were asked to identify stakeholders that they considered important for the process. Two categories of stakeholders constitute the network:

- Core stakeholders are those whose actions and decisions have a direct influence on land management, they are affected by land degradation and soil erosion in the area, and have a strong interest in preventing and mitigating these threats.

Stakeholders in this category will be more actively involved in the participatory learning activities, and they are sub-divided into local and external stakeholders:

- Local stakeholders are those who live in the area, they know the rural landscape characteristics and have site-specific knowledge and land management experience (e.g. land users/owners, community leaders).
- External stakeholders are those who have interest and work within the specific rural environment, they have different levels of professional experience on soil-related issues, and are able to suggest and evaluate alternative SLM practices (e.g. researchers, public and civil society officers working on relevant issues).

- Secondary stakeholders are those selectively engaged in the participatory process, for example through expert interviews, or by receiving information on the activities within the study area (e.g. policy makers, the media and the general public).

Participatory Identification of SLM options

Stakeholder workshops are the cornerstone of the followed participatory approach and bring together actors with different experiences and perspectives, thus offering an interactive basis for combined thinking towards a shared vision (Schwilch *et al*., 2009). The aim of the first workshop was the participatory identification of existing and potential prevention, remediation and restoration options to address soil erosion by water in the study area. To create an appreciative working atmosphere and enable mutual trust and open-minded attitudes, the workshop was organised in a mountain community within the study area in November 2014. The workshop was structured to follow a logical and

consecutive sequence of interactive exercises, directly related to the local context, and was facilitated by two moderators who guided the process. The major steps are shown in Table I.

Assessment of SLM options identified

The WOCAT inventory questionnaires (www.wocat.net) were used as a documentation and appraisal tool for the assessment of the SLM options identified by stakeholders. The WOCAT framework focuses on evaluating both the conservation technologies and their implementation approaches, which are jointly referred to as SLM practices (Liniger & Schwilch, 2002). The technology questionnaire focuses on agronomic, vegetative, structural and management conservation measures, or a combination of these, and addresses the specifications, the natural and human environment where it is implemented, and the impact of each technology (i.e. advantages and disadvantages, economic impacts, acceptance and adoption). The approach questionnaire addresses how the implementation of a SLM practice is achieved and by whom, by documenting the objective, the operation and participation, the inputs and means (e.g. material, financial, etc.), the necessary know-how (e.g. technical, scientific, etc.) and the levels of intervention (i.e. from individual farm applications to the context of national or international initiatives). Each identified SLM option was evaluated in consultation with experts from the established stakeholder network. Four focus group meetings were organised with expert stakeholders willing to share their knowledge regarding the aspects of each technology; additional information was also collected from the WOCAT database and the literature. Similarly, the potential implementation approaches were explored in focused group meetings with local community leaders, a

representative of farmers' unions and an expat association (i.e. families that have moved to the urban areas but still own properties in the research site).

Selection of SLM option for implementation

A second stakeholder workshop was organised in July 2015. The aim was for stakeholders to jointly select a SLM option for implementation, monitoring and evaluation at the research site; the major workshop steps are shown in Table I. Having reached a consensus among participants regarding the objective of the SLM options identified and assessed earlier by stakeholders (i.e. to reduce soil erosion and land degradation in mountain communities), the selection was based on a comparative process of ranking evaluation criteria and scoring of options against those criteria. Evaluation criteria representing the three sustainability dimensions (i.e. 7 economic, 7 environmental and 6 socio-cultural criteria) were pre-selected by the interdisciplinary team of seven researchers from the full list of 70 criteria in the WOCAT technology questionnaire (Liniger *et al*., 2008), considering the land degradation issues in the area and the SLM options at stake. The stakeholders first voted on the 20 criteria to rank them in order of importance. The top 12 criteria (4 per category) were selected for the scoring of SLM options (see Appendix S1).

The scoring was undertaken in three rotating groups, one for each sustainability dimension. Scoring values ranged from 1 (very bad) to 5 (very good). Following the first scoring round, one expert from each group remained to enlighten the next group, while the rest of the group moved on to the next dimension. The groups could adjust the initial scores by no more than 1 score point. Scores were subsequently normalised using a linear function ($v = 0.25v_0 - 0.25$, where v is the normalized score and v_0 is the original score).

The normalized scores were weighted, based on the importance order of the criteria. Instead of allocating weights arbitrarily, the range of all possible combinations of weighted scores was computed as follows (Yakowitz & Weltz, 1998):

$$s_{kj} = \frac{1}{k}\sum_{i=1}^{i=k} v_{ij}$$
$$Max\ S_j = \max(s_{kj})$$
$$Min\ S_j = \min(s_{kj}) \quad (1)$$

where v_{ij} is the normalised score of option j for criterion i, s_{kj} are weighted scores for option j, k is an index for the weighted scores ($k = 1, n$), n is the number of criteria, $Max\ S_j$ is the best possible score and $Min\ S_j$ is the worst possible score for option j. The above equations automatically ensure that the scores are weighted by the importance order of the criteria ($W_1 \geq W_2 \ldots \geq W_n$) and that the sum of the weights is equal to one ($\sum_{i=1}^{n} w_i = 1$). Data analysis was implemented in an Excel workbook. A range of weighted scores was computed for all criteria together and for each sustainability dimension separately.

A moderator guided the participants through the consecutive steps, and assisted the exchange of ideas towards selecting a promising option that best meets the specific conditions of the local human and natural environment. The results were displayed in plenary for evaluation, and to assist the negotiations among participants towards the final decision (Schwilch *et al.*, 2012).

RESULTS AND DISCUSSION

Identification of stakeholders and SLM options

The stakeholder identification process was undertaken with regular site visits and interaction with local and external actors, and proved to be very important and useful. The snowball sample started with 9 institutions and 23 stakeholders identified by the research team, while stakeholders identified 6 more institutions and 52 additional stakeholders (Figure 3). Information on the role and influence of different stakeholders on land management and abandonment was collected through conversations rather than following a typical interview format. Knowing who the stakeholders are ensures the engagement of the 'right' actors at different stages of the transdisciplinary research process (Lang et al., 2012). As pointed out by Cuppen (2012), the engagement of non-experts, and especially marginalised local actors, in a way that allows real effect in the process, enables a wider range of opinions to be contested and discussed. Furthermore, researchers were positioned as stakeholders in the process rather than as outsiders or more powerful actors. As Bracken *et al*. (2015) note, this does not only facilitate better communication and effective knowledge exchange, but also empowers stakeholders to perceive the process more positively when feeling that their views and opinions are equally weighted to those of scientific experts.

Twenty four representatives of the wider stakeholder environment from the established network were invited to attend the workshop; 12 local (i.e. land users and community leaders) and 12 external (including officers of public institutions, scientists and NGO representatives). The step-by-step procedure of the first workshop improved everyone's understanding of the causes and effects of land degradation at the research site. Although most stakeholders – and especially the local actors – did not initially perceive soil erosion as an imminent threat, progressively the discussion revealed drivers

and problems associated to land management and soil erosion in mountain communities. This was partly due to the background information provided to stakeholders and the awareness raised during the workshop regarding the biophysical aspects of soil functions and soil threats. The on-site observations helped to visualise the land degradation issues in the area, with local stakeholders sharing their knowledge and experiences. The main issues identified were the following:

- Unmaintained terraces and gradual collapse of dry stone walls as a result of rural depopulation, land abandonment and soil erosion. The stability of terraces is determined by the building technique, the location, the slope and the crops grown. Terrace abandonment is associated with the socio-economic changes in the area and the profitability of farming in mountain environments.
- Dieback of fruit and nut trees and susceptibility to fires due to land abandonment, and higher temperatures and lower precipitation amounts over time.
- Soil erosion in and resulting from the rural unpaved road network, driven by intense precipitation events.
- Root rot associated with poor drainage and water-logging as a result of substandard dry-stone terrace building techniques.

The interest of stakeholders was also reflected during the group discussions and diagramming of existing and potential solutions. The integrated knowledge of local and external actors resulted in a total of 15 solutions, ranging from “soft” (e.g. awareness-raising) to more “technically advanced” solutions (e.g. road maintenance). The options were discussed in a plenary session and were prioritised through voting, to enhance their

suitability, appreciation and ownership. The four options selected for further assessment and appraisal are shown in Table II.

It is often the case that during participatory processes, hidden aspects and stakeholder interests that are not obvious at first glance are discovered (Reed *et al*., 2009; Herweg & Steiner, 2002). Soil erosion in and from the unpaved road network – an issue not previously raised – was highlighted by local land users during and after the observation walk. Furthermore, the interest of most local stakeholders was dominated by socio-economic aspects such as insufficient subsidy schemes. In general, although the workshop structure and content was well appreciated by participants, some local actors had more conservative and pessimistic views than the external stakeholders (including the research team) on the effectiveness of voluntary initiatives in maintaining dry-stone terraces. These findings were taken into account during the next step of the process.

SLM assessment and selection

The WOCAT inventory questionnaires were used as a starting point to evaluate each SLM option, in consultation with local and external experts. While relative knowledge abundance was found regarding the technologies, the proposed approaches were associated with more site specific issues and were – to a certain extent - focused on improving organisational structures, especially at the local level. In addition, three out of four options involved interventions on privately owned terraces, meaning that the owners had to be identified and then convinced to cooperate in implementing them. To overcome this issue, as well as the scepticism raised by some workshop participants, the potential ways in which the proposed approaches could be implemented were further explored in the mentioned focus meetings with community leaders and a representative of farmers'

unions and an expat association. Considering the willingness of the local focus group to cooperate, the spontaneous response of the research team to overcome these issues was to test the implementation of community-based maintenance of degraded dry-stone terraces on selected fields. Therefore, local and scientific stakeholders agreed to co-organise a public terrace maintenance event prior to the second workshop; the approach is described in the next section.

The second workshop was attended by 16 local and 15 external stakeholders. The features of each technology were presented by local and external experts, while the respective approaches were outlined by the moderator. The added value of this procedure was the direct response and clarification of questions raised by participants. The rotating group-scoring of options against ranked criteria was perceived positively by participants. Figure 4 shows the final normalised criteria scores per SLM option, after the three group-scoring rounds. Terrace rehabilitation had the highest scores for all criteria compared to the other three options, except for the "low cost" criterion. The performance of SLM option per category was evaluated using Equation 1 and is shown in Figure 5. These results were presented to stakeholders and facilitated the negotiations regarding the trade-offs of each option in relation to the three sustainability dimensions. Terrace rehabilitation had the best mean overall performance score (0.78), followed by crop diversification (0.77) and afforestation (0.72). Stakeholders agreed that the rehabilitation of dry-stone terraces was the preferred option. They noted that it is a well-established practice that fits within the local socio-cultural contexts and has high environmental benefits, despite the higher cost compared to other practices. The comprehensive

WOCAT questionnaires were then completed for the selected option (codes T_CYP004en and A_CYP001en in the www.wocat.net database).

From selection to implementation

Between the first and the second stakeholder workshops, the research team envisioned a small scale demonstration event to test the potential implementation of community-based terrace maintenance activities. The community leaders agreed on the organisation of a pilot event in Platanistasa. Following the success of the first event, the other two community leaders expressed their interest in organising similar events in their respective communities. The hosting community gave each event its own character. In Platanistasa, the community selected a degraded terrace on the main road to the communities to ensure visibility. The community arranged sun-protection tents and requested police presence to ensure road safety; a bag of Cypriot village flour was given at the end to each participant, as a symbol of gratitude for their aattendance. At the second event, in Alona, a presentation on the technical and cultural aspects of dry-stone wall construction was given in the community hall, prior to the hands-on maintenance. The terrace selected for reconstruction was inside the village and many people stopped by to watch and chat. In Polystipos, the leading local expert, notwithstanding his advanced age, managed to instruct everyone in the art of dry-stone wall construction and a beautiful terrace was built along the road. In all events, easily accessible sites were identified by community leaders and terrace experts and the site-selection was finalised in cooperation with the research team, after the approval of land owners was obtained. Locally-sourced stones were provided by the communities. All events were advertised with flyers and posters in central locations within the communities, in social media, and through personal

communication. In total, 164 people attended the three events; 51% have their residence beyond the three communities while 26% of the participants were female.

Key actors for the implementation of the approach were identified from the network of stakeholders; these are community leaders, terrace experts, local institutions (i.e. expat associations and farmers' unions) and extension services. The main target groups in terms of engagement and motivation in the learning-by-doing activities are land users and land owners, mountain community inhabitants and other interested stakeholders (Figure 6). During the practical (i.e. hands-on) public events, local dry-stone experts had the leading role as they explained the best practices in terms of maintenance techniques, and guided the event's attendees in collectively restoring collapsed or poorly maintained terraces (Figure 7). It is worth noting that all stakeholders were engaged in the implementation of the approach on a voluntary basis. Furthermore, the events provided the opportunity for awareness-raising of a wide audience on the environmental and cultural importance of dry-stone terraces.

Implications, constraints and outlook

The community-based approach has been initiated in an effort to to reduce soil erosion and to maintain the production capacity of soils in the terraces of the Troodos Mountains. Moreover, the approach aims to strengthen science-society cooperation in solving land degradation issues, by building the capacity of local communities in terms of planning, organisation and implementation of participatory soil-conservation activities. By its nature, the construction and maintenance of dry-stone terraces is a laborious practice that relies on indigenous knowledge. Thus, the approach is also aiming at

maintaining this traditional know-how through community engagement and joint-learning activities between land users, terrace experts and interested stakeholders.

Research based on interdisciplinary methods and participatory principles can potentially empower marginalised communities, once external actors have a better understanding of the complex, dynamic and multi-scale nature of socio-ecological systems (Berkes, 2004). Frequent interaction with key local stakeholders created conditions of mutual trust, which led to the co-development and implementation of the terrace rehabilitation approach. Yuliani *et al*. (2015) note that the use of indigenous knowledge as the basis for community empowerment is critical for successfully implementing community-based approaches. Kieninger *et al*. (2013) found that the main motivations of volunteers participating in maintaining rice terraces in Japan are the spiritual value and beauty of cultural landscapes. Furthermore, community-based approaches can be strengthened when activities focus on building social capital, improve the socio-economic well-being of local people and promote local leadership, creativity and resilience, instead of relying on monetary incentives (Prety & Smith, 2004). The experience from implementing the community-based approach in Cyprus concurs with these findings, as the process helped build the self-confidence of sceptical local actors. In addition, some volunteers were keen to learn about indigenous agronomic practices while others joined the events to reconnect with their roots.

The restoration of degraded terraced landscapes requires continuous attention and combined efforts of multiple stakeholders, as this task cannot be solely assumed by a small group of dry-stone experts. The constraints and potential responses for implementing the approach are summarised in Table III. As an initial step, the

community-based rehabilitation approach has sparked the interest and has been appreciated by local and external actors. To this end, the communities have agreed to co-organize another series of events this year and engage more people. Furthermore, five mountain communities in Cyprus beyond the research site have expressed their interest in adopting the approach and organise similar events. In the short-run the positive spirit can be maintained by organising such cooperative activities. However, these efforts alone would be insufficient to restore and maintain the terraced landscape and the challenge remains in enhancing the positive SLM impact in the long-run. It is also important to assess the impact of such initiatives by integrating quantitative and qualitative approaches.

Beyene (2015) notes that externally introduced community-based rehabilitation initiatives may fail when land users put emphasis only on short-term economic gains. On the contrary, collective actions, awareness of impacts and designing of institutions, contribute to effective SLM adoption and can potentially generate income streams in the long-run. In other words, the success of the rehabilitation efforts depends on the long-term provision of environmental and socio-economic benefits for the mountain communities. Torquati *et al*. (2015) found that the financial success or failure of investments in restoring traditional terraced vineyards in Italy is not only determined by the socio-economic context but by the ability of land users to differentiate their products. Terrace maintenance can benefit by combining the peculiar landscape characteristics with agro-tourism, cultural or leisure activities, and by improving post-harvest processing and marketing of agricultural products. Tarolli *et al*. (2014) also stressed the importance of involving active people and the younger generation in terraced land management. It is

also critical that information and knowledge of best practices, arising from the implementation of community-based processes, reach policy-makers and enhance their understanding towards designing more effective rural development policies.

CONCLUSION

This paper presented the participatory framework followed to select SLM approaches to control soil erosion in the Troodos Mountains of Cyprus. Key local and external stakeholders were identified and invited to participate in interactive workshops. The rehabilitation of abandoned and collapsing dry-stone terraces was considered by stakeholders as the preferred practice, having high environmental benefits and good suitability for the local socio-cultural context, and despite being a more expensive solution compared to other options. Three mountain communities implemented the selected option by co-organising communal rehabilitation events, where dry-stone experts guided volunteers in restoring collapsed terrace walls. To increase the impact of this approach, visible and easily accessible sites were selected. In the first year of implementation, a total of 164 people attended the events. To maintain the positive momentum, stakeholders suggested another series of events, which has been scheduled for the coming season. In the long-run, the sustainability of this initiative can be achieved by institutionalising the approach, by actively engaging young people in terrace land management, and through cooperation with agro-tourism businesses. Furthermore, community activities for improving the profitability of local farming, such as through the differentiation of local products and a value chain approach, should be explored. Finally, measuring and showing stakeholders differences in sediment loss from degraded and maintained terraces can provide further motivation for rehabilitation.

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REFERENCES

Agnoletti M, Conti L, Frezza L, Monti M, Santoro A. 2015. Features Analysis of Dry Stone Walls of Tuscany (Italy). Sustainability 7: 13887-13903.

Arnáez J, Lana-Renault N, Lasanta T, Ruiz-Flaño P, Castroviejo J. 2015. Effects of farming terraces on hydrological and geomorphological processes. A review. Catena 128: 122-134.

Berkes F. 2004. Rethinking community-based conservation. Conservation Biology 18: 621-630.

Beyene F. 2015. Incentives and Challenges in Community-Based Rangeland Management: Evidence from Eastern Ethiopia. Land Degradation & Development 26: 502-509.

Blaikie P. 2006. Is small really beautiful? Community-based natural resource management in Malawi and Botswana. World Development 34: 1942-1957.

Bracken LJ, Bulkeley HA, Whitman G. 2015. Transdisciplinary research: understanding the stakeholder perspective. Journal of Environmental Planning and Management 58: 1291-1308.

Camera CA, Apuani T, Masetti M. 2014. Mechanisms of failure on terraced slopes: the Valtellina case (northern Italy). Landslides 11: 43-54.

Caspari T, Ruiperez-Gonzalez M, van Lynden G, Bai Z, Bachmann F, Schwilch G. 2015. Selection of SLM practices to be tested and evaluated. ISRIC: Wageningen & CDE: Bern.

Caspari T, van Lynden G, Bai Z, Mantel M, Bachmann F, Schwilch G. 2014. Participatory identification of measures to combat soil threats in Europe. ISRIC: Wageningen & Bern: CDE.

Cuppen E. 2012. Diversity and constructive conflict in stakeholder dialogue: considerations for design and methods. Policy Sciences 45: 23-46.

CyStat. 2012. Population Census 2011. Cyprus Statistical Service, MoF, Nicosia.

CyStat. 2014. Census of Agriculture 2010. Cyprus Statistical Service, MoF, Nicosia.

Djuma H, Bruggeman A, Camera C, Zoumides C. 2016. Combining qualitative and quantitative methods for soil erosion assessments: an application in a sloping Mediterranean watershed, Cyprus. Land Degradation & Development, DOI: 10.1002/LDR.2571.

European Commission. 2009. Council Regulation (EC) No 73/2009. Official Journal of the European Union L 30/16, Brussels.

European Commission. 2013. Council Regulation (EC) No 1305/2013. Official Journal of the European Union L 347/487, Brussels.

García-Ruiz JM, Lana-Renault N. 2011. Hydrological and erosive consequences of farmland abandonment in Europe, with special reference to the Mediterranean region–a review. Agriculture, Ecosystems & Environment 140: 317-338.

Herweg K, Steiner K. 2002. Impact Monitoring and Assessment: Instruments for Use in Rural Development Projects with a Focus on Sustainable Land Management. CDE: Bern.

Kieninger PR, Penker M, Yamaji E. 2013. Esthetic and spiritual values motivating collective action for the conservation of cultural landscape–A case study of rice terraces in Japan. Renewable Agriculture and Food Systems 28: 364-379.

Koulouri M, Giourga C. 2007. Land abandonment and slope gradient as key factors of soil erosion in Mediterranean terraced lands. Catena 69: 274-281.

Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ. 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustainability Science 7: 25-43.

Lasanta T, Arnáez J, Oserín M, Ortigosa LM. 2001. Marginal lands and erosion in terraced fields in the Mediterranean mountains: a case study in the Camero Viejo (Northwestern Iberian System, Spain). Mountain Research and Development 21: 69-76.

Lesschen JP, Cammeraat LH, Nieman T. 2008. Erosion and terrace failure due to agricultural land abandonment in a semi-arid environment. Earth Surface Processes and Landforms 33: 1574-1584.

Leventon J, Fleskens L, Claringbould H, Schwilch G, Hessel R. 2016. An Applied Methodology for Stakeholder Identification in Transdisciplinary Research. Sustainability Science [under review]

Liniger H, Schwilch G, Gurtner M, Mekdaschi SR, Hauert C, van Lynden G, Critchley W. 2008. A Framework for Documentation and Evaluation of Sustainable Land Management – Technologies Basic WOCAT Questionnaire. WOCAT-CDE: Bern.

Liniger H, Schwilch G. 2002. Enhanced decision-making based on local knowledge. Mountain Research and Development 22: 14-18.

Ludwig D. 2001. The era of management is over. Ecosystems 4: 758-764.

Pereira P, Mierauskas P, Novara A. Stakeholders perception about fire impact in Lithuanian protected areas. 2016. Land Degradation & Development 27: 871-883.

Pretty J, Smith D. 2004. Social capital in biodiversity conservation and management. Conservation biology 18: 631-638.

Reed MS, Graves A, Dandy N, Posthumus H, Hubacek K, Morris J, Prell C, Quinn CH, Stringer LC. 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. Journal of Environmental Management 90: 1933-1949.

Rolé A. 2007. The terraced landscapes of the Maltese islands. In Europe's living landscapes, Essays exploring our identity in the countryside, Pedroli GBM, van Doorn AM, De Blust G, Wascher DM, Bunce F (eds). KNNV publishing; 405-420.

Schneider F, Fry P, Ledermann T, Rist S. 2009. Social learning processes in Swiss soil protection–The 'From farmer-to farmer'project. Human Ecology 37: 475-489.

Schwilch G, Bachmann F, De Graaff J. 2012. Decision support for selecting SLM technologies with stakeholders. Applied Geography 34: 86-98.

Schwilch G, Bachmann F, Liniger HP. 2009. Appraising and selecting conservation measures to mitigate desertification and land degradation based on stakeholder participation and global best practices. Land Degradation & Development 20: 308-326.

Tarolli P, Preti F, Romano N. 2014. Terraced landscapes: from an old best practice to a potential hazard for soil degradation due to land abandonment. Anthropocene 6: 10-25.

Torquati B, Giacchè G, Venanzi S. 2015. Economic analysis of the traditional cultural vineyard landscapes in Italy. Journal of Rural Studies 39: 122-132.

UNESCO. 2014. Florence Declaration on the Links between Biological and Cultural Diversity (Florence, Italy, 11 April 2014). URL: http://www.uniscape.eu/allegati/FLorence-UNESCO-CBDJP_Inst.pdf, accessed in January 2016.

Vieira RMSP, Tomasella J, Alvalá RCS, Sestini MF, Affonso, AG, Rodriguez DA, Barbosa AA, Cunha APMA, Valles GF, Crepani E, DeOliveira SBP, DeSouza MSB, Calil PM, DeCarvalho MA, Valeriano DM, Campello FCB, Santana MO. 2015. Identifying areas susceptible to desertification in the Brazilian northeast. Solid Earth 6: 347-360.

Vila Subirós J, Rodríguez-Carreras R, Varga D, Ribas A, Úbeda X, Asperó F, Llausàs A, Outeiro L. 2015. Stakeholder Perceptions of Landscape Changes in the Mediterranean

Mountains of the North-Eastern Iberian Peninsula. Land Degradation & Development, DOI: 10.1002/ldr.2337.Widgren M. 2007. Pre-colonial landesque capital: a global perspective. In Rethinking Environmental History: World-system History and Global Environmental Change, Hornborg A, McNeill JR, Martinez-Alier J (Eds.). Altamira Press: Lanham; 61–77.

Wolfgramm B, Shigaeva J, Dear C. 2015. The Research–Action Interface in Sustainable Land Management in Kyrgyzstan and Tajikistan: Challenges and Recommendations. Land Degradation & Development 26: 480-490.

Xie LW, Zhong J, Chen FF, Cao FX, Li JJ, Wu LC. 2015. Evaluation of soil fertility in the succession of karst rocky desertification using principal component analysis. Solid Earth 6: 515-524.

Yakowitz DS, Weltz M. 1998. An algorithm for computing multiple attribute additive value measurement ranges under a hierarchy of the criteria: application to farm or rangeland management decisions. In Multicriteria analysis for land-use management. Springer: Netherlands; 163-177.

Yuliani EL, Adnan H, Pierce Colfer CJ, Indriatmoko Y. 2015. Problem-solving versus appreciative inquiry approaches in community-based conservation. Forests, Trees and Livelihoods 24: 97-111.

Figure 1. Location, topography and land use of the research site

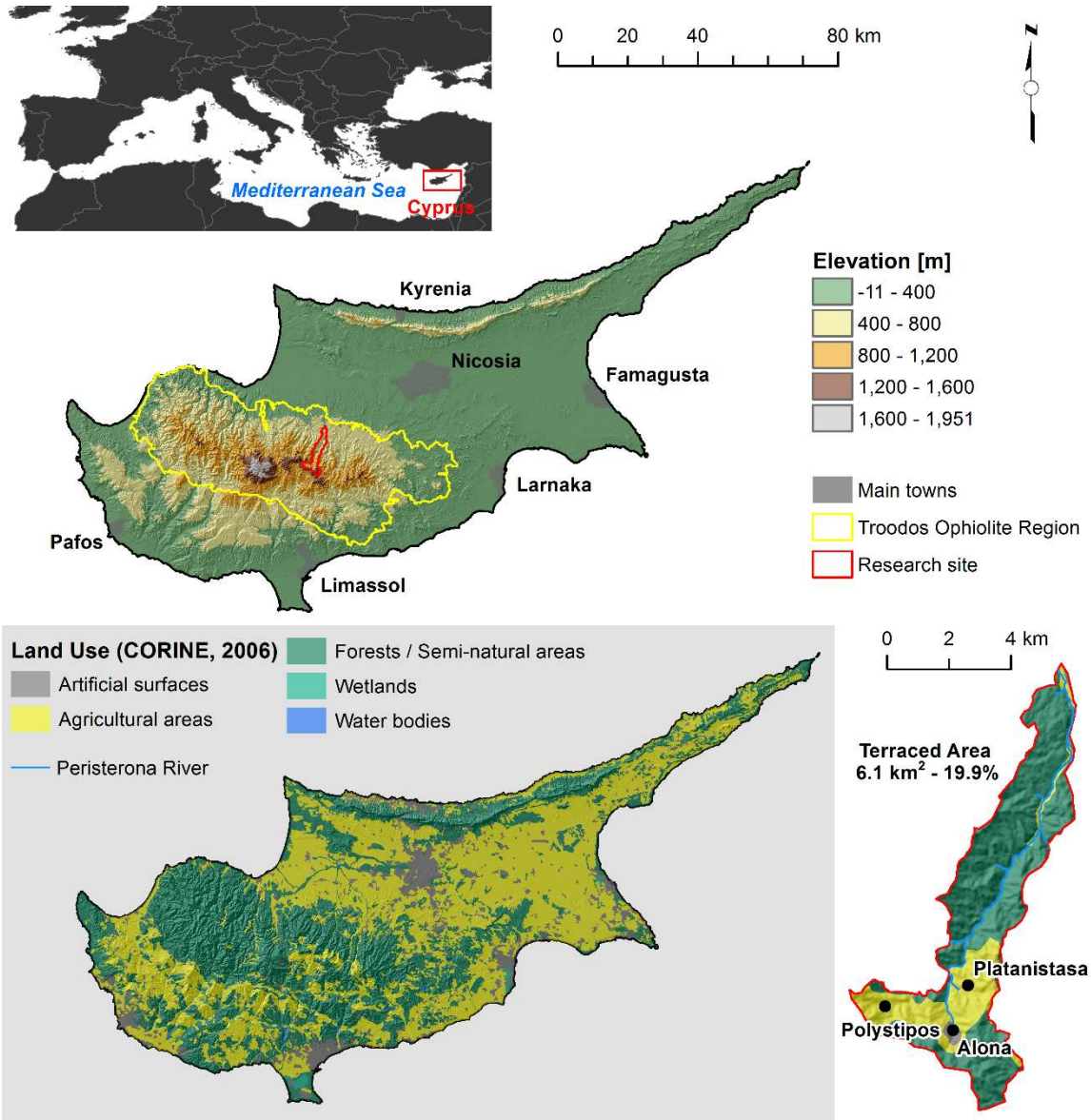

Figure 2. Unmaintained and collapsing dry-stone terraces in Polystipos community

Figure 3. Local and external institutions and stakeholders identified by structured snowball sampling

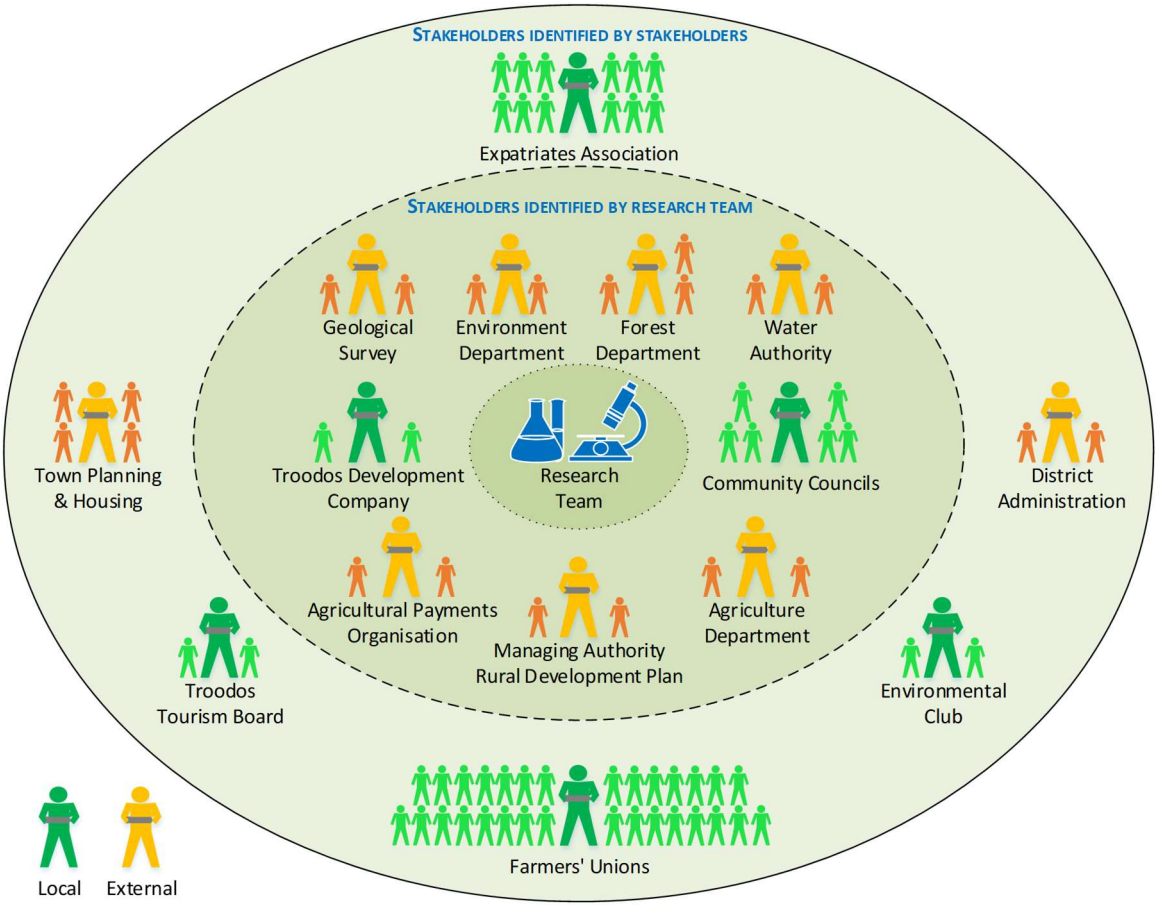

Figure 4. Overview of normalised scores per SLM option and ranked criteria in order of importance, as per the stakeholder votes (ECN: Low cost had received the most votes); the acronyms ECN, ECL and SOC indicate the economic, ecological and socio-cultural criteria categories, respectively

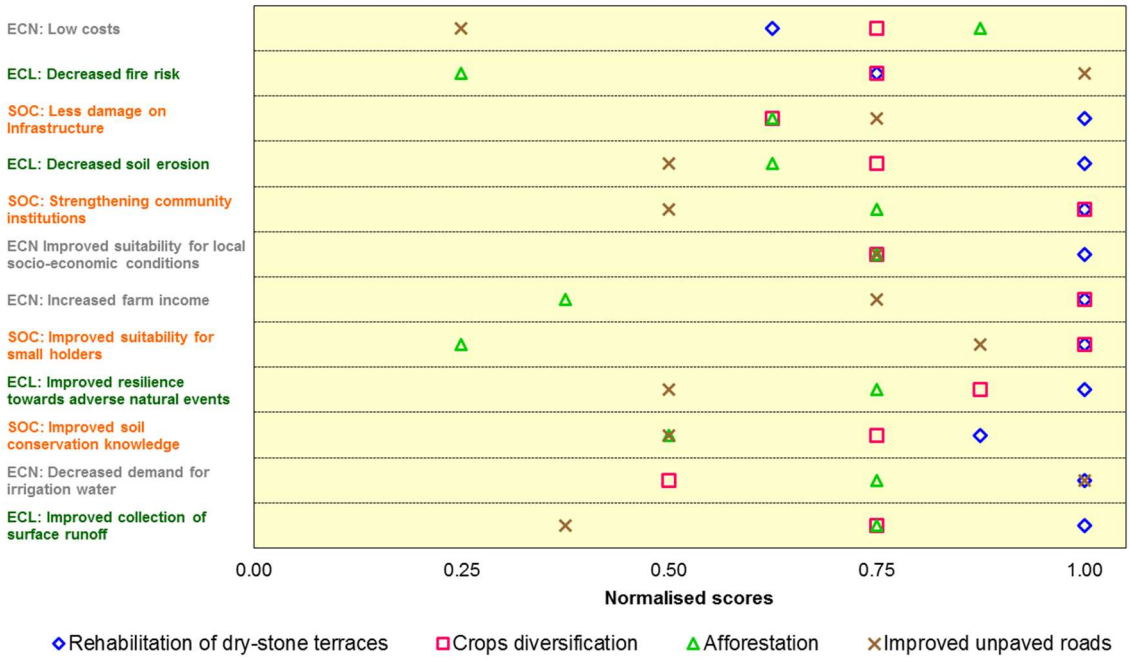

Figure 5. Range of scores per SLM option and sustainability dimension; the bar's positon indicates its performance relative to other options

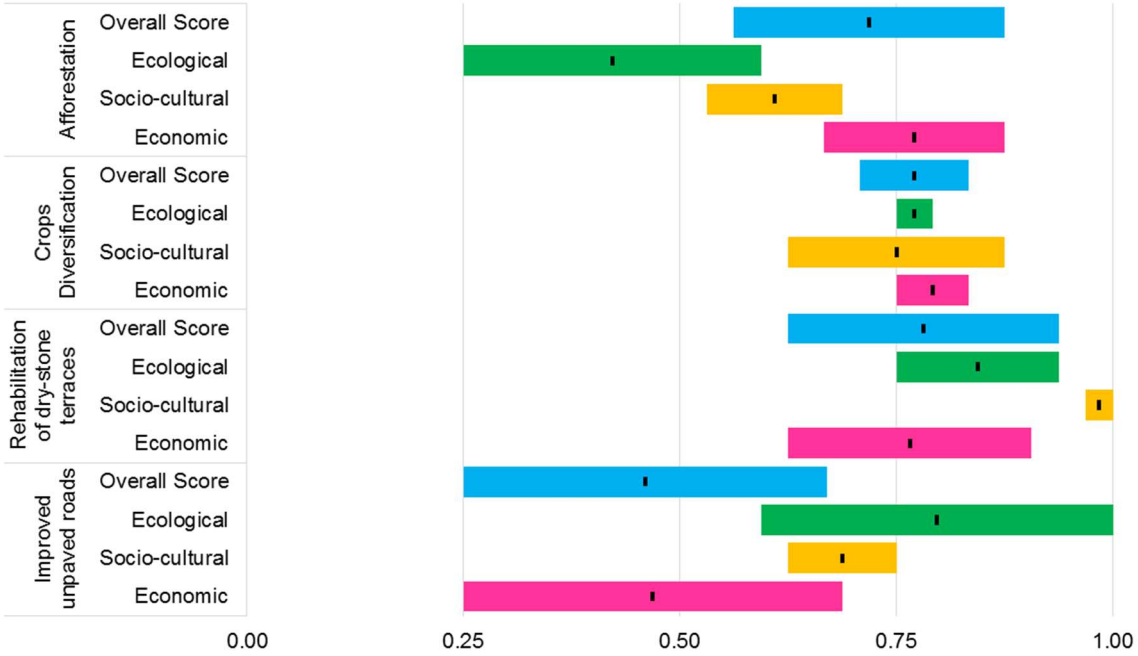

Figure 6. Organogram of the approach

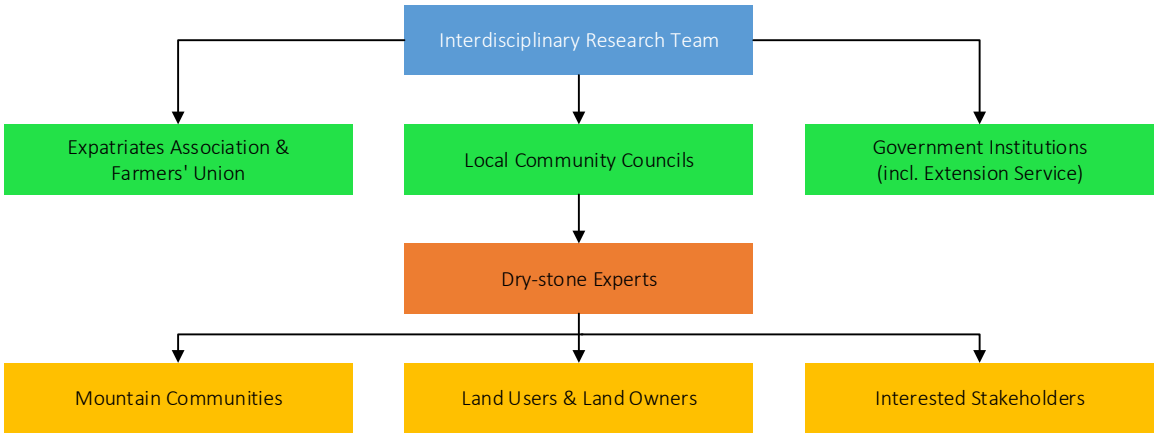

Figure 7. Experts guiding volunteers during public terrace maintenance events

Table I. Sequence of 1st and 2nd workshop exercises

	Exercise	Objective	Method
1st Workshop	Influence and motivation of stakeholders in the area	Establish a pleasant working atmosphere, give participants the opportunity to present themselves and get an overview of stakeholder influence and motivation regarding sustainable land management in the area	Picture gallery and stakeholder matrix (influence and motivation)
	Land degradation and conservation in the area	Identify (i) soil erosion threats at the site, (ii) current and potential prevention, mitigation and restoration options for soil conservation	Group walk, on-site observations and discussions, followed by group work (discussion and documentation), plenary session (presentation and discussion)
	Assessment of identified land management options for soil conservation	Assess and prioritise applied and potential options	Group discussion and prioritisation through individual voting
2nd Workshop	Clarifying the objective	Clarify and establish consensus on the objective of SLM options	Plenary presentation and discussion
	Overview of SLM options	Update all participants on the SLM technologies and approaches under evaluation	Plenary presentation of technologies (by respective experts) and approaches (by moderator)
	Ranking of evaluation criteria	Understand the use of criteria and assign hierarchy	Plenary discussion and individual voting
	Scoring of options	Score SLM options against criteria	Rotating group work
	Data analysis and interpretation	Visualize, discuss and interpret results	Multi Objective Decision Support System and plenary discussion
	Negotiation and decision-making	Reach agreement and commitment of stakeholders on how the selected option should be applied	Plenary discussion

Table II. Potential SLM solutions identified by stakeholders

Technology	Approach
Hydrologically-sound, unpaved mountain roads	Multi-stakeholder cooperation for construction and maintenance of hydrologically-sound, unpaved roads in mountainous areas
Agricultural terraces with dry-stone walls	Community-based maintenance and rehabilitation of agricultural terraces in mountain environments
Crop diversification	Diversification to low input and high value crops (e.g. herbs) on mountain terraces
Afforestation of abandoned and degraded terraces	Improvement of extension services for the establishment and maintenance of natural vegetation (e.g. forests) on abandoned and degraded mountain terraces

Table III. Constraints and responses for implementing the community-based terrace maintenance approach

Category	Constraint	Response
Technical	Loss of indigenous knowledge	The terrace events are led by dry-stone experts to practically demonstrate and pass the technical know-how to the next generation. Efforts were made to engage terrace experts from different communities
Workload	Terrace maintenance is a laborious activity	The community-based approach aims to engage and build the capacity of a large group of people in terrace maintenance
Social-cultural	Land abandonment, rural depopulation and lack of motivation	Organise and advertise terrace maintenance events frequently to stimulate the interest; invite and engage local communities and land owners (including expats) to participate. The terrace events also turned into social happenings, with various people joining just to watch and chat.
Legal	Terraced land is privately owned, thus implementation of community-based maintenance requires the approval of land owners	Community leaders request the approval of land owners
Institutional	No formal terrace maintenance institutions	Maintain cooperation and organise events on annual basis in the short-run and gradually institutionalise the process to sustain the positive impact on land management in the long run.
Financial	High terrace maintenance cost	Engage, motivate and train volunteers through hands-on terrace maintenance events