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APPRAISING AND SELECTING STRATEGIES TO COMBAT AND MITIGATE DESERTIFICATION BASED ON STAKEHOLDER KNOWLEDGE AND GLOBAL BEST PRACTICES IN CAPE VERDE ARCHIPELAGO

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ABSTRACT

Desertification is the most disturbing and detrimental cause of rural vulnerability in Cape Verde, affecting families' material and environmental resources. Combating desertification in Cape Verde is complex because it involves addressing a mixture of endogenous (manual agriculture, fuel wood and fodder extraction, land tenure and steep slopes) and exogenous drivers (high rainfall variability, climate change, prolonged drought or heavy rainfall). To address and mitigate the adverse effects of desertification, it is necessary to develop an approach that identifies and brings together all the key stakeholders affected by and acting on the desertification issue, including land users, policy makers, managers, researchers and rural development technicians. This paper presents a hybrid methodology based on global best practices, applied in Cape Verde. It combines experiences and skills of local stakeholders (farmers, local association of land users and local non-governmental organizations) with scientific knowledge of external stakeholders such as technicians of the Ministry of Rural Development, environmental advisors of Municipalities and researchers. Integration takes place following a participatory process of appraising and selecting desertification control strategies. The paper presents the first results obtained from application of the hybrid methodology to Ribeira Seca, the largest watershed of Santiago Island. The approach was evaluated with local and external stakeholders. Both groups appreciated that they could voice their views and discuss ways to overcome barriers and also to take full advantage of the opportunities offered by jointly selected promising desertification mitigation options. Copyright © 2013 John Wiley & Sons, Ltd.

KEY WORDS: sustainable land management; scientific and local knowledge; participatory decision-making; small-scale agriculture

INTRODUCTION

Cape Verde is considered part of Sahelian Africa, where drought and desertification are common occurrences. The main activity of the rural population is rain-fed agriculture, which over time has been increasingly challenged by high temporal and spatial rainfall variability, lack of inputs, limited land area, fragmentation of land, steep slopes, pests, lack of mechanization and loss of top soil by water erosion. Human activities, largely through poor farming practices and deforestation (Gomez, 1989) have accelerated natural erosion processes, shifting the balance between soil erosion and soil formation (Norton, 1987). According to previous studies, vegetation cover is one of the most important factors in controlling soil loss (Cyr *et al*., 1995; Hupy, 2004; Zhang *et al*., 2004; Zhou *et al*., 2006). For this reason, reforestation is a touchstone of the Cape Verdean policy to combat desertification.

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After Independence in 1975, the Cape Verde government had pressing and closely entangled environmental and socio-economic issues to address, as long-term desertification had resulted in a lack of soil cover, severe soil erosion and a scarcity of water resources and fuel wood. Across the archipelago, desertification was resulting from a variety of processes including poor farming practices, soil erosion by water and wind, soil and water salinity in coastal areas due to over pumping and seawater intrusion, drought and unplanned urbanization (DGA-MAAP, 2004). All these issues directly affected socio-economic vulnerability in rural areas, where about 70% of people depended directly or indirectly on agriculture in 1975. By becoming part of the Inter-State Committee for the Fight against Drought in the Sahel in 1975, the government of Cape Verde gained structured support to address these issues more efficiently. Present-day policies and strategies were defined on the basis of rational use of resources and human efforts and were incorporated into three subsequent national plans: the National Action Plan for Development (NDP) (1982–1986), the NDP (1986–1990) and the NDP (1991–1995) (Carvalho *et al*., 1994). As these policies were implemented, thousands of structures to collect and conserve rainwater such as **calderas** (half-moon terraces), soil bunds, contour furrow walls, check dams, dams, terraces, protective walls, water pipes, '*Espelho de captação*' (water harvesting infrastructures with three entities: collecting area, reservoir and a water drainage system, which links the two first entities), water extraction from thin stretched canvas and domestic tanks fed by home slate roof, and wells were built, and millions of trees of various species were planted throughout the archipelago. During the 1982–1995 period, 22% (89,900 ha) of the national territory was afforested with more than 62 tree species, largely dominated by broadleaf species (95%) (MDR, 2013). Currently, 25% of farmers' income comes from the livestock sector, which plays an important role in household food security, but despite the increase in the number of animals, the sector continues to face serious problems including a lack of pasture. Combating desertification in Cape Verde is still very challenging. Climate change, drought, lack of natural resources, limited arable land, land tenure, low rain-fed agriculture yields, poverty, unemployment, rural exodus, scarce water and water conflicts are some of several socio-economic impacts induced by desertification.

Until the late 1990s, farmers' involvement in these soil and water conservation works was based on 'FAIMO' (High Intensity Man Power Labour). This provided them with temporary paid work to alleviate their immediate household needs while reducing rural unemployment (Haagsma, 1990; MDR-CFDR, 1995). The approach was top-down, without meaningful, active participation of the land users from the problem definition stage. Although successful, the performance could be improved if the technical measures are fit to the priorities of local stakeholders and the socio-economic context. Several studies demonstrate that the best way to efficiently fight desertification and achieve better natural resource management is to actively involve affected populations in developing solutions, leveraging their knowledge and experiences and combining them with the knowledge of researchers and managers in all steps of plans, programmes or projects (Fraser *et al*., 2005; Reed *et al*., 2005; Stringer & Reed, 2007; Gabathuler *et al*., 2011; Reed *et al*., 2011).

The aim of this paper is to present the lessons learned from the application of a hybrid methodology that combines local experiences and skills of farmers and scientific knowledge in a participatory process of appraising and selecting desertification control strategies. This is the first time such an approach has been applied in Cape Verde. The approach combines interactive learning and decision-making with local best practices. It includes six steps: i) identification of land degradation symptoms and current soil and water conservation practices in an initial stakeholder workshop; ii) the study of key indicators of land degradation; iii) identification of pilot technologies to combat land degradation in a second stakeholder workshop; iv) implementation of selected technologies by local stakeholders; v) the evaluation and monitoring of technologies carried out by a multidisciplinary team; and vi) presentation of the first results and identification of strategies to disseminate the results in a final stakeholder workshop. We further discuss the main lessons from this case with reference to scaling up to other watersheds in Santiago and other islands and in transferring the approach to other countries.

MATERIAL AND METHODS

Cape Verde Archipelago with ten small islands (Figure 1) is located about 500 km off the West Africa coast. Agriculture is the main activity of the rural population, which constitutes about 46% of the total population. In Cape Verde, agriculture is strongly limited by the scarcity of arable land and water resources. Arable land covers only 10% of the total land area, and the production of those lands corresponds only to about 10% of national needs. This emphasizes the food insecurity level. Scarcity of resources, together with low yields, poverty and population growth, creates a real

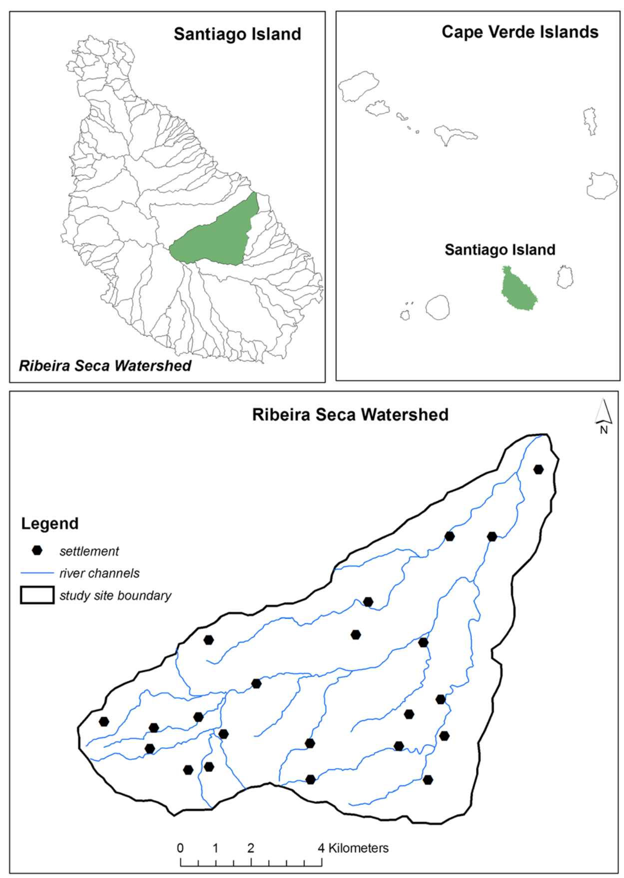

Figure 1. Study site geographic location. This figure is available in colour online at wileyonlinelibrary.com/journal/ldr.

challenge in achieving sustainable and integrated environmental management.

The study was conducted in Santiago Island, which has a surface area of 991 km^2. It is the main arable region of Cape Verde, with more than 56% of all arable land. More than 90% of the island's inhabitants depend on agriculture. Although rain-fed agriculture is not a priority sector for economic development, agriculture and livestock employ a very broad sector of the population.

All research activities have been concentrated in Ribeira Seca, the largest watershed of Santiago Island (Figure 1). Corn and beans are the principal crops in this watershed, with a few forested areas in the higher hills (400–1,394 m asl) (Bertrand, 1996). Ribeira Seca, with four bioclimatic areas: arid, semi-arid, sub-humid and mountainous humid areas (Dinis & Matos, 1986), has a drainage area of about 71·5 km^2 and is populated by around 15,000 people. The area has very good infrastructure, having in the past benefitted from several actions to conserve soil and water (Lopes & Meyer, 1993; Ferreira *et al*., 2011). Unfortunately, desertification is still rife (Tavares, 2011a; Tavares *et al*., 2011). Several stakeholders, in particular land users, municipality decision makers, agricultural non-governmental organizations (NGOs) and researchers operate within the watershed, each with different interests and approaches, making it a suitable site for implementation of the approach as explained in the succeeding text.

The methodology consists of six steps that build a methodological framework to appraise and select sustainable land management options suited to the Ribeira Seca watershed, stakeholder preferences and desertification intensity (Figure 2). The approach is outlined in detail in Schwilch (2012), Schwilch *et al*. (2009, 2012) and Reed *et al*. (2011) and is here presented as a novel case study of its application. Integral to the framework was the implementation of three stakeholder workshops (Schwilch *et al*., 2009).

Information about the landscape, land and water resources, climate and soil and water conservation practices in the study area was obtained from the literature (Faria, 1970; Dinis & Matos, 1986; Lopes & Meyer, 1993; Bertrand, 1994, 1996; Smolikowsky *et al*., 2000; Spencer, 2002; MAAP-DGPOG/DEGI, 2004; Pina *et al*., 2005). Existing practices were documented and evaluated by applying locally questionnaires (WOCAT, 2008; WOCAT/LADA/DESIRE, 2008) developed at the global scale for sharing of local knowledge in similar contexts around the world (WOCAT, 2007; Schwilch *et al*., 2009, 2011).

The next paragraphs present the steps taken to implement the approach:

Step 1 (socialization and identification of main causes and consequences of land degradation) was realized during the first stakeholder workshop (WS1), which was organized over

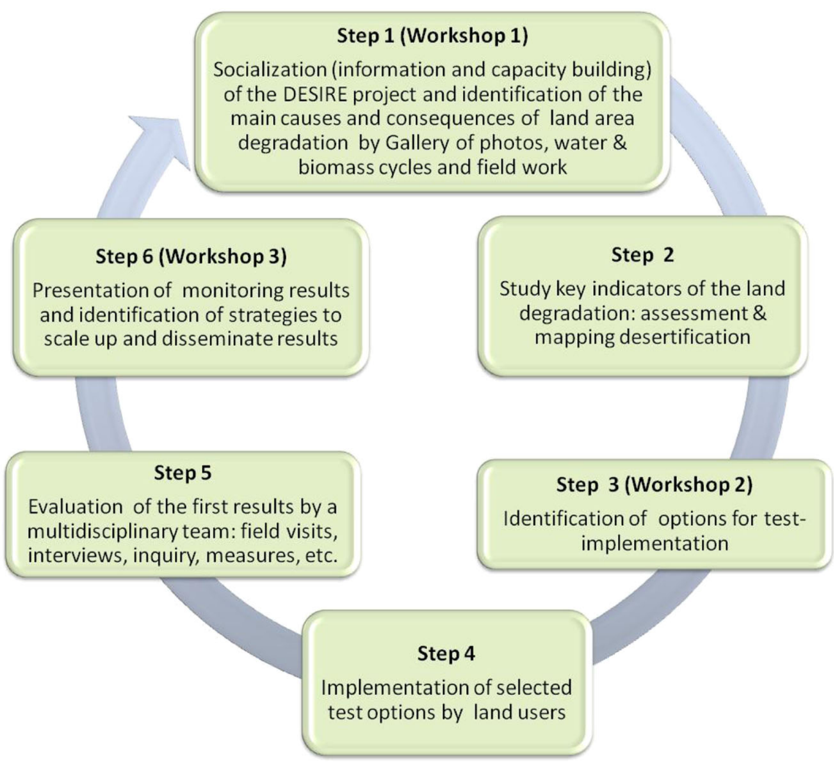

Figure 2. Outline used to engage local and external stakeholders to work together for combating land degradation and improving yield from rain-fed agriculture in the study site of Ribeira Seca. This figure is available in colour online at wileyonlinelibrary.com/journal/ldr.

3 days. On day 1, the DESIRE project was introduced to participants and an inventory of the various consequences of land degradation in the study area was given (Tavares & Reis, 2008). Day 2 consisted of a stakeholder field visit to the study area to identify symptoms of erosion and desertification and to discuss the causes and also the possible impacts of land degradation. On the final day, opportunities for addressing land degradation and desertification problems were discussed.

Step 2 (key indicators of land degradation) adapted indicators from Kosmas *et al.* (1999) to the Cape Verde context and mapped desertification risk in the study site in order to better understand desertification through the use of indicators and to orientate project intervention. Few such indicator-based approaches have been applied to assess, monitor and evaluate changes in the quality of land resources and desertification in Cape Verde. At the national, island, municipality and watershed scales, key indicators can help to indicate priorities for policy development and budgetary allocation by governments, local governments (municipalities), NGOs and rural development projects, providing a proper foundation for policy formation and decision-making on matters affecting land resources at all scales and levels (Pieri *et al.*, 1995). The land degradation indicators from Kosmas *et al.* (1999) of six data sets: climate, soils, vegetation, land management, erosion and social aspects were assessed and fed into ArcGIS 9·2 software. The main input data for calculating these indices include land surveying, soil samples and laboratory analyses; soil, water and erosion measurements; flood frequency and drainage density; population density and age; and climatic data (from Meteorology and Geophysical Institute of Praia). Several target points were sampled according to the Manual for describing land degradation indicators (Kosmas *et al.*, 1999). The Medalus model (Kosmas *et al.*, 1999) was used to integrate the main data set indicators according to the equations:

$$\text{Desertification risk} = (\text{SQI*CQI*VQI*MQI*WRQI*SoQI})^{1/n} \tag{1}$$

Where:

SQI, soil quality index; CQI, climate quality index; and VQI, vegetation quality index.
MQI, management quality index; WRQI, water erosion quality index; and SoQI, social quality index. All index values range between 1 (best) and 2 (worst).

$$\text{Quality}_X = [(\text{Indicator}_1)*(\text{Indicator}_2)*(\text{Indicator}_3)*\ldots(\text{Indicator}_n)]^{1/n} \tag{2}$$

Where: each quality index of Equation 1 is based on indicators scored as very high (when the score value is 1), high, moderate, low or very low (when the score value is 2), with ‘n’ equal to the number of indicators.

This methodology has been recently applied to a similar environment (Izzo *et al.*, 2013).

Step 3 [selection of two options (live barriers and afforestation), among five options, for test implementation by farmers] comprised a second stakeholder workshop (WS2) (Schwilch *et al.*, 2009). Participants and moderators were the same as in WS1. The workshop sought to i) identify relevant criteria on which stakeholders can rely to judge or rank options, ii) score all options by these criteria, iii) rank the criteria, iv) analyse option with Decision Support System software supporting the evaluation and v) develop a decision-making process and select options for implementation. To be useful, a criterion should i) differentiate between options, ii) be assessed and iii) be important to at least one person among the 36 people included in the process. Scoring involved assigning each option a value concerning the question: how well does the option fulfil the criteria? It quantifies the effects of the options on the criteria. Criterion scores ranged from 1 (worst performance) to 10 (best performance). The criteria were grouped under three categories: economic, environmental and social. Analysis and interpretation consisted of visualizing the relative merits of the options and understanding the results. Analysis was performed with Facilitator Decision Support System software. This uses decision rules, a hierarchical system for ranking criteria, score functions and linear programming to identify a preferred management option consistent with the ranking of the decision criteria (Bachmann *et al.*, 2008). Results are presented in bar graphs, giving a visual representation of the relative merit of each option. Each option is represented by a green bar showing the range of overall scores for that option. Local stakeholders participated in all phases of this step. This was not the case for researchers, whose role as external stakeholders consisted of working out the results with the Facilitator software.

In *step 4*, (implementation of two test options by farmers) the objectives were to implement the selected options identified in WS2. These were in accordance with bioclimatic zone realities, and their effect on soil cover was measured according to Herweg (1996). Sediment accumulation behind pigeon pea species was measured with a metric tape. To implement test options, it was necessary to select target fields according to their biophysical context (size, type of soil and water conservation measures in the field, rainfall and slope) and the socio-economic reality (gender equity, size of each family, labour availability and financial capacity) of land users and estimate the implementation budget according to the price of seeds, plants and monitoring system of options. Afforestation species used are fruit trees. Some were planted on land where irrigation water is available, and the others were planted near the homes of farming families. Each land user received about four to five plants.

Step 5 (evaluation of the first results by a multidisciplinary team: field visits, interviews, inquiry and measurements) evaluated the two selected actions (live barriers and afforestation), and was conducted by a multidisciplinary team comprising at least one member of each group of actors involved in the process [a representative of local farmers' associations, a representative of NGOs, a representative of the Ministry of Rural Development, two representatives of the Municipalities, a representative of The General Direction of Rural Development, the national focal point of the United Nations Convention to Combat Desertification (UNCCD) and three researchers]. Evaluations were conducted on nine farmer plots and the different stakeholders also documented their findings in the form of video.

In *step 6* (presentation of monitoring results and identification of strategies to scale up and disseminate results during stakeholder workshop 3—WS3), results obtained during steps 4 and 5 were presented to all participants of WS3. Workshop participants then discussed the strategies to be adopted to ensure dissemination of results to a larger scale, that is, to expand from the watershed scale to the municipality or the entire island. Stakeholder surveys were undertaken to better evaluate option implementation effects. Participants selected as member of the multidisciplinary team for surveys participated in WS1 and WS2.

RESULTS AND DISCUSSION

In *step 1*, 35 stakeholders participated in WS1, including 18 local and 17 external stakeholders; 35% of participants were women.

In *step 2* (study of key indicators of land degradation), six dataset layers were combined to assess the desertification sensitivity of the study site area. Results show that vegetation, water erosion and soil present low to very low environmental quality for, respectively, 79%, 74% and 60% of the study area. Figure 3 shows the distribution of environmental risk areas in Ribeira Seca watershed. Areas at very high and high risk from desertification are found in the central parts, where the climate, soil, vegetation and management quality are low. In the watershed of Ribeira Seca, 45% of the area (32·1 km^2) shows high and very high desertification risk. Areas of moderate risk to desertification correspond to the high altitude areas and represent 29% (21 km^2) of the area. Eastern and western parts of the area are characterized by a very low and low risk to desertification, representing 6% and 14% of the total area, respectively. The present desertification risk map identifies and prioritizes the high-erosion risk areas and creates awareness amongst stakeholders.

In *step 3*, a second stakeholder workshop with 26 participants was held. Information and data obtained during WS1 (Tavares & Reis, 2008) and field data (Tavares *et al.*, 2012) permitted better identification of the consequences of

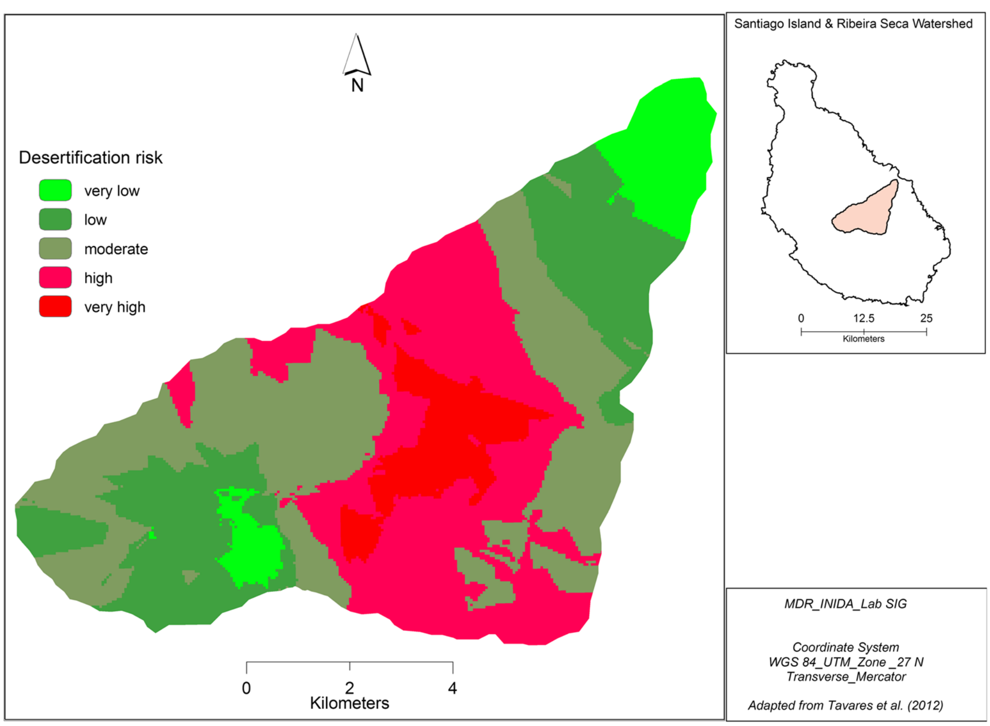

Figure 3. Desertification risk map of Ribeira Seca (Tavares *et al.*, 2012). This figure is available in colour online at wileyonlinelibrary.com/journal/ldr.

desertification during the second stakeholder workshop. Several desertification characteristics were identified: loss of top soil, rill and gully erosion; low soil fertility; water scarcity; soil salinity in the littoral areas; and siltation of hydraulic infrastructures (Figure 4). Six criteria per category (environmental, economic and social) were selected in two working groups (land users, NGOs and farmer associations group and City Hall, technicians and researchers group) to better facilitate communication, then discussed and prioritized in plenary. During the presentation of scores by working groups, we noted some differences between scores from local and external stakeholders. To gain consensus, we adopted a stratagem, which consisted of three options: to take the average between the scores of the two groups, to accept the score given by one group in consensus or to discuss in plenary a new score. The results of scoring are provided in Table I. Figure 5 shows a graph with quantitative range values (from 0 'very low' to 0·5 'acceptable' to 1·0 'very high'). For environmental and social categories, afforestation and live barriers present, respectively, the better scores; for the economics category, the rehabilitation of Longueira small dam and hydraulic infrastructures ranked the highest.

Across all categories, the stakeholders' appraisal and selection converge to focus on two options: afforestation and live barriers. These rank well in all three categories. Stakeholders defined several strategies to reach a better

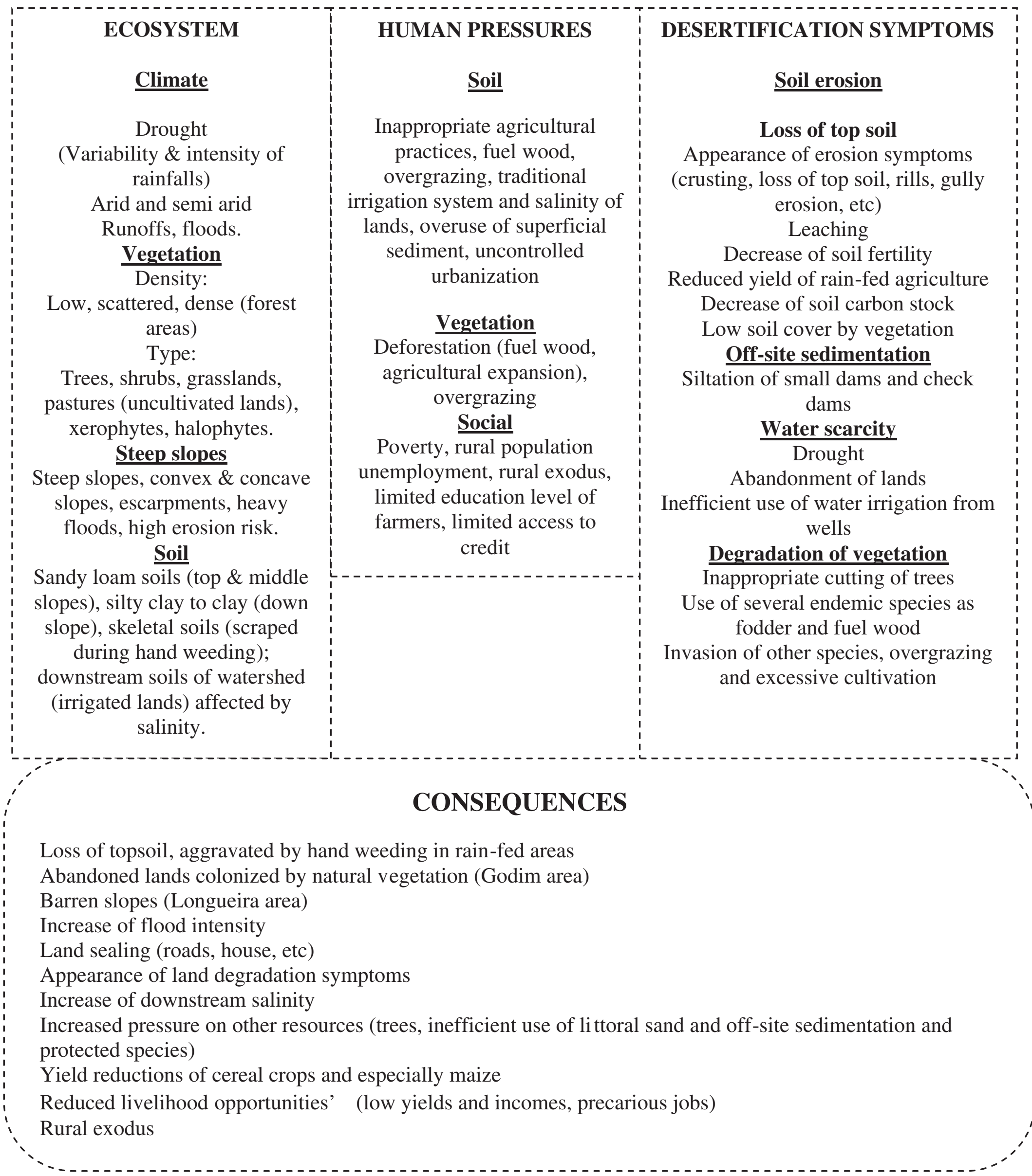

Figure 4. Processes and consequences of desertification in Ribeira Seca watershed. Source: Authors' creation.

Table I. Results obtained by combining criteria score between scorings of two working groups respectively representing local stakeholders and scientific and political stakeholders

	Categories and criteria																	
	Ecological						Economic						Social					
Options	SC	DOS	DOSL	DOS	DSRO	EGW	CY	LS	FP	IWA	IF	ROL	GE	CBLD	FS	He	CM	CSO
LB	8	5	8	6	9	6	8	8	8	6	7	9	7	9	7	8	8	9
Af	10	9	10	6	8	8	6	6	8	7	7	9	8	9	8	8	9	8
WHS	4	6	8	10	8	9	9	10	9	10	10	8	6	7	9	7	8	5
CSW	5	8	8	7	6	8	6	6	7	7	6	8	5	8	6	5	7	4
SDSM	4	7	3	9	8	9	9	9	5	10	10	5	7	6	10	6	7	6

Options: LB, live barriers; Af, afforestation; WHS, water harvesting system; CSW, contour stone walls; SDSM, small dam of Santa Maria.
Ecological criteria: SC, soil cover; DOS, diversification of species; DOSL, decrease of soil loss; DOS, decrease of salinity; DSRO, decrease surface runoff; EGW, exploitation of ground water.
Economic criteria: CY, crop yield; LS, livestock; FP, fodder production; IWA, irrigation water availability; IF, income of farmers; ROL, recuperation of land.
Social criteria: GE, gender equity; CBLD, capacity building in land degradation; FS, food security; He, health; CM, conflict mitigation; CSO, cultural and scientific opportunities.

way to implement measures against land degradation and desertification (Table II).

In *step 4*, national project researchers held several meetings with farmers' association members to determine the two options chosen (afforestation and live barriers). Regarding afforestation, farmers opted for fruit trees (mango, avocado, papaya, etc). Live barriers as option number one and afforestation as option number two were implemented in 49 farmers' plots. More than 75% of farmers opted for *Cajanus cajan* (L.) Sw. (pigeon pea, locally known as **Congu**), whereas others preferred *Aloe vera* (L.) Burm. f. (local name: **Babosa**) and *Leucaena leucocephala* (Lam.) De Wit. (locally known as **Linhaço**). Pigeon pea was implemented only in rain-fed areas and live barriers in three agro-ecological zones (humid, sub-humid and semi-arid). Afforestation was adopted in the humid and sub-humid zones and also in irrigated lands (arid zone). Afforestation is realized in areas where rainfall is regular (wet mountains) and also where water is available for irrigation, like Poilão Dam. About 1,200 fruit trees were planted by two farmer groups, whose members, respectively, live and practice rain-fed agriculture (corn and bean) in the wet mountains areas of Picos, Covada, Longueira and Ribeirão Galinha or practice irrigated agriculture in the humid valleys of Poilão Fonseca and Macati. Pigeon pea can be cultivated both in planting holes and live barriers. The two practices were adopted in several rain-fed areas such as Picos, Covada and Longueira, except in arid areas. Farmers received seeds to treat their own rain-fed plots from OASIS (Association Group of Santiago Land Users) and COVADA (Local Land Users Association of Covada Region), in the following proportions:

i) 88% of beneficiaries adopted random seeding or planting holes, the combination of pigeon pea and maize made in a random way. Some agreed to fully treat their land with the pigeon pea. The first strategy (planting of pigeon pea and maize in the same hole) is a local practice used to improve the land and to facilitate infiltration. The second strategy is generally adopted where land fertility is low. It permits soil fertility rehabilitation after 2 or 3 years and also increases pigeon pea yield, fodder availability and water infiltration;
ii) 7% of land users treated their plots in the form of sharp barriers; and
iii) Others adopted the two techniques (planting hole and barriers) together.

The planting hole is a common rain-fed farming practice in Cape Verde, called '**coba pingado**'. The hole spacing changes from regions to regions. In irrigated lands, the strategy is implemented as a line hole system (locally called '**coba recto**').

The live barrier strategy is a new technique, introduced on Santiago Island in the 1990s with several species. This strategy consists of pretreating the land with several horizontal

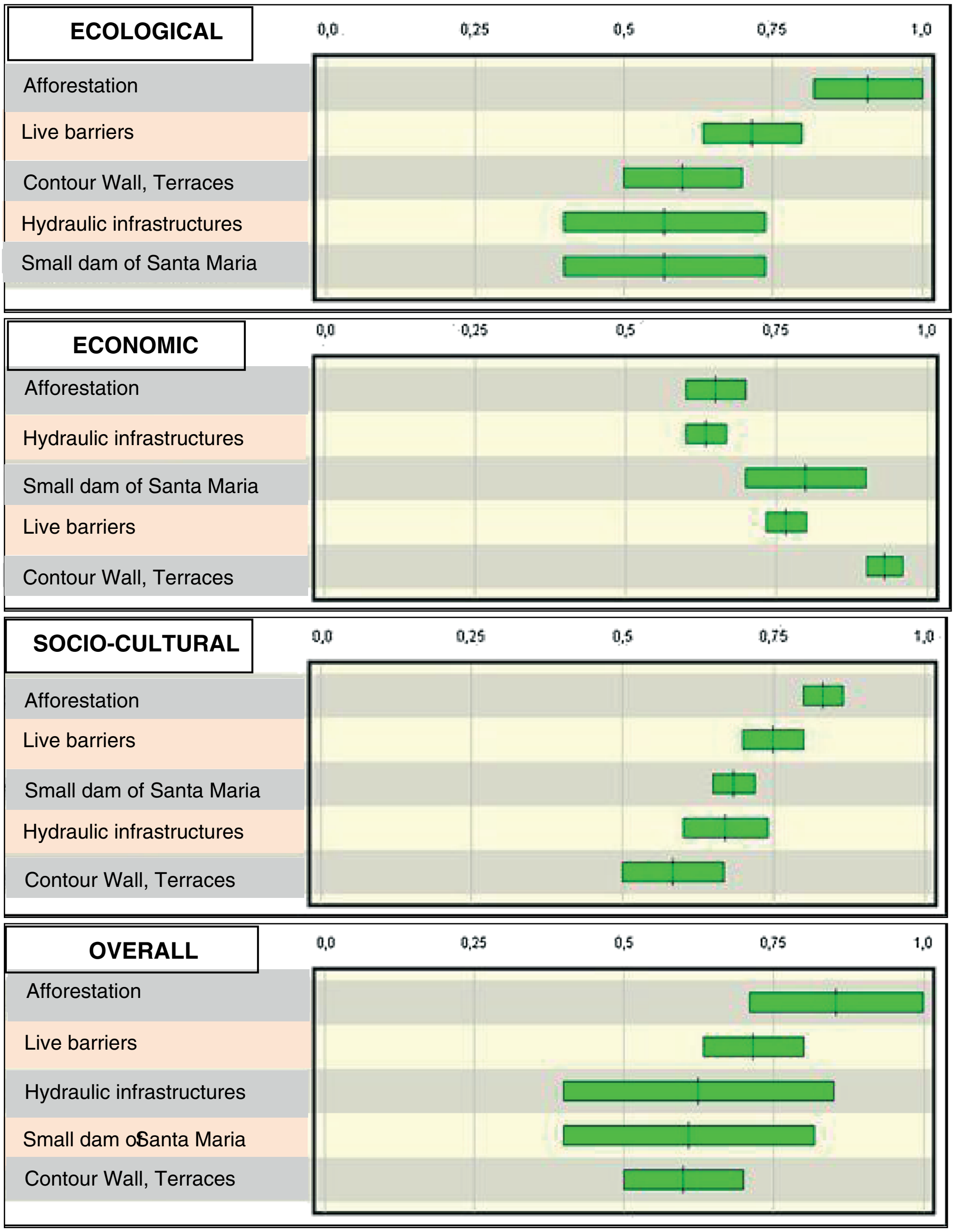

Figure 5. Performance of desertification remediation options as elaborated by and presented in stakeholder workshops using Facilitator software. Each green bar represents an individual option. The bar width indicates the range of scores that a given option received, and the bar's position indicates its performance relative to the other options (Tavares & Baptista, 2009). This figure is available in colour online at wileyonlinelibrary.com/journal/ldr.

line barriers across the slope, at a horizontal interval of about 6 m. Line delimitation is done with a locally constructed easel made of wood with a level to determine the slope contours. After the contours are marked with stones, the farmer can dig lines with a hoe for subsequent planting of pigeon pea along the lines (Figure 6). Pigeon pea live barriers permit farmers to continuously grow maize and beans between pigeon pea line barriers over several years (Figure 7). According to field measurements performed on two adjacent parcels in the region of 'Orgãos Pequenos' to 'Achadinha' upstream of Ribeira Seca, environmental effects are promising. In the plots treated with pigeon pea live barriers, vegetation covered 40% of arable land and the dry vegetation cover under plants from the defoliation of pigeon pea leaves or mulch can reach 43% from the second year (Table III). In other plots treated with pigeon pea in planting holes, pigeon pea vegetation cover after 2 years reached 87% according to field measurements. Pigeon pea's impact against soil

Table II. Stakeholders' strategies for implementation of desertification remediation options as discussed in workshop 3

Objectives*	Appropriate technologies (what?)	Most adequate approach (how?)	Responsible stakeholders (who?)	Monitoring and evaluation (who and how?)
Eliminate/reduce disturbances in cycles				
↗ production ↘ erosion and desertification ↗ quality of life	Slopes and riverbed protection	Participatory	Local community	MDR; municipalities; farmer associations
↗ knowledge level ↗ of production and ↗ of performance	Capacity building	Accessible language	Local community	MDR; general direction of adult alphabetization/ education
↗ of production and ↘ of poverty ↕ rural exodus ↘ emigration	Longueira Dam rehabilitation		Community living upstream of Ribeira Seca	MDR; municipalities; researchers associations;
↗ products of animal origin	Improvement of animal production	Animal raisers training	Local community; population, and consumers	MDR; Municipalities; researchers; NGOs; associations
National product valorization ↘ of importation ↗ of the animal raisers' income		• Technical assistance • Production factors *(animal feed, improved breeds and pasture.)*		
Fulfilment of laws ↗ of inspection	Institutional and legal capacity strengthening	Training of inspectors Population sensitization	Population	MDR; MIT; municipalities; researchers; NGOs

NGOs, non-governmental organizations; MDR, Ministry of Rural Development.
*Some objectives make reference to desired development: ↗ = increase and ↘ = decrease.

Figure 6. Rain-fed plot (maize and bean culture) in Achadinha area after harvesting without sustainable land management practices (left) during the dry season (22/7/11). The same plot (right) during installation (22/7/11) by farmers (contour lines were outlined with a wood easel equipped with a level; this tool was conceived by INIDA researchers, and farmers were trained to use it in the field). After this step, the farmers plant pigeon pea seeds along the contour line. This figure is available in colour online at wileyonlinelibrary.com/journal/ldr.

erosion is also positive: field measurements of soil sedimentation behind the stems showed an accumulation that varied between 8- to 15-cm and 5- to 7-cm thickness, respectively, for live barriers and planting holes, which are impressive values. These values first show the intensity of weeding by hand, which removes the arable land top soil, and second the sheet erosion induced by rainfall.

The pigeon pea planting hole strategy allows better soil cover as a consequence of greater density of vegetation cover than other species such as *Aloe vera* (Tavares, 2011b). Therefore, there is less evaporation, reduced impact of raindrops on the soil, less runoff and more infiltration. Additionally, atmospheric nitrogen is captured in the soil through pigeon pea biological nitrogen fixation and by improved recycling of N through plant residues, minimizing soil N losses (George *et al.*, 1992). The pigeon pea crop, according to the results of field assessments (Table III), provides good soil cover, demands less water and lower soil

Figure 7. Plot with pigeon pea in live barriers and maize between live barriers during the humid season (24/10/12) 2 years after installation (left). Right, the same plot after maize harvesting and pigeon pea with less leaves (defoliation period) during the dry season (2/4/13). This figure is available in colour online at wileyonlinelibrary.com/journal/ldr.

fertility and represents a real alternative to low-yielding maize production. In addition to ecological improvements, pigeon pea provides a more nutritious fodder than dry maize fodder for livestock and has good seed production. According to stakeholder inquiry data, pigeon pea yield (dry seed) varied from 1·9 to 1·8 Mg ha^{-1}, respectively, for years 1 and 2 in the planting hole strategy. Pigeon pea yield is lower in the live barriers strategy (0·7 to 0·4 Mg ha^{-1}). Live barrier yields were lower than planting hole yields because they only occupy 35–40% of the rain-fed agriculture plot, but the live barrier system permits farmers to produce both pigeon pea and maize. With regard to the fruit trees, it is difficult to measure their impact in the short term because of their slow growth. However, the survival rate is almost 100% because of good planting conditions and monitoring conducted by beneficiaries.

Step 5. Nine stakeholder video clips were made (www.desire-his.eu/en/ribeira-seca-cape-verde), and all interviewed stakeholders found that the participatory approach and the methodology used were very good. The approach gave the stakeholders the opportunity to be part of the project. The UNCCD national focal point stated: 'The objectives of the DESIRE project meet the goals of UNCCD and the results should be applied to other watersheds in Cape Verde'. Stakeholders evaluated the pigeon pea technology positively in terms of production, improvement of land, soil fertility and decreased wind erosion. Female farmers recommended other land users to plant pigeon pea because it helps women to feed their children, get extra income, enriches soil and protects land (Baptista & Tavares, 2011). Mr Didi, a farmer and the Official Advisor of Banana local association in Godim said in 'his' video clip:

> the approach is very interesting because the implementation of pigeon pea in the Banana area has permitted to protect the arable lands and the pigeon pea leaves enrich the soil and conserve the lands, avoiding hand weeding with hoe. I advise my friends to use pigeon pea.

Step 6 entailed a final stakeholder workshop with 36 participants, more than 98% of whom had also participated in the two previous workshops. So far, hundreds of farmers have received about four to five fruit tree seedlings. Although 2 years of monitoring and evaluation are relatively few, initial results were seen as very encouraging by the beneficiaries and warranted dissemination at a much broader scale. The following recommendations were adopted by the participants during the workshop:

- The local/regional policies that could promote wide adoption of the strategy may include the National Action Plan to Combat Desertification prepared under the UNCCD, the Municipal Action Plan to Combat Desertification, the Municipal Development Plan and the National Action Plan for Environment
- Field survey of potential areas to apply the technology
- Identification of funding sources
- Education of land users
- Wide scale dissemination
- Make field visits between farmers, that is, transmission of experiences and results obtained with the pigeon pea by the beneficiary farmers to other farmers who have not yet adopted the pigeon pea practice.

To facilitate widespread dissemination of the technology, workshop participants defined several tasks and responsibilities of each stakeholder group (Table IV). To guarantee successful widespread implementation of the technology, some key policy messages were adopted by stakeholder groups: farmers should be the centre piece in the widespread implementation of soil and land management (SLM) technology and be involved in decision-making regarding SLM; NGOs and extension officers should educate and inform land users about desertification issues, prevention and mitigation strategies, and decision makers should legislate on the use of SLM technologies like cultivation of pigeon pea on steep

Table III. Pigeon pea implementation parameters on rain-fed lands cropped with maize

Parameters	Value
Plot tested (n°)	49
Firsts plot measured: planting hole and live barriers plots (n°)	3
Area treated (ha)	8·18
Farmers (n°)	43
Gender equity (%)	
Female	56
Male	44
Local stakeholder land management strategies (%)	
Live barrier	7
Planting hole	88
Soil cover with pigeon pea live barriers during wet season (%)	
Before planting pigeon pea	<2
First year after planting pigeon pea	18
Second year after planting pigeon pea	44
Soil cover with planting hole pigeon pea during wet season (%)	
Before planting pigeon pea	<2
First year after planting pigeon pea	35
Second year after planting pigeon pea	48–87
Dry organic mulch under pigeon pea live barriers during dry season (%)	
Before planting pigeon pea	<5
First year after planting pigeon pea	28
Second year after planting pigeon pea	43
Dry organic mulch under planting hole pigeon pea during dry season (%)	
Before planting pigeon pea	<5
First year planting pigeon pea	31
Second year planting pigeon pea	60
Sediment flux measurements (cm) in plot with pigeon pea as live barriers	
Before planting pigeon pea	<1
First year after planting pigeon pea	1–2·5
Second year after planting pigeon pea	8–15
Sediment flux measurements (cm) in plot with pigeon pea as planting hole	
Before planting pigeon pea	<1
First year after planting pigeon pea	1–2·5
Second year after planting pigeon pea	57
Pigeon pea dry seed yield (t ha) in planting hole	
Before planting pigeon pea	<0·19
First year after planting pigeon pea	1·9
Second year after planting pigeon pea	1·8
Pigeon pea dry seed yield (t ha) in live barrier	
Before planting pigeon pea	<0·19
First year after planting pigeon pea	0·7
Second year after planting pigeon pea	0·4

Table IV. Task and responsibilities in the dissemination process of pigeon pea

Stakeholder groups	Responsibility
Farmers	Implementation, maintenance and conservation of technologies
	Participation in capacity building, participatory research and monitoring
NGOs	Funding (acquisition of seeds, training, etc.)
	Empowerment of local communities (capacity building and follow-up)
Municipality	Funding (acquisition of seeds and training)
	Planning, monitoring, facilitation/articulation
INIDA	Research and technical assistance
	Monitoring and dissemination
DGADR and delegations of MDR	Capacity building of farmers and technical assistance for land users
	Funding, monitoring and legislation
National Focal Point of Convention to Combat Desertification	Information of projects/programmes on the combat of desertification
	Information on existing global mechanisms for funding

Source: Adapted from Baptista & Tavares (2011).
DGADR, Direção Geral da Agricultura e Desenvolvimento Rural; NGOs, non-governmental organizations.

rain-fed lands. The implementation of a participatory approach increases the acceptance and therefore the overall impact of SLM techniques. The approach tested in this study can be adopted in regions where several constraints prevent a widespread SLM adoption to tackle both food insecurity and large-scale soil degradation (Wildemeersch *et al.*, 2013). Pigeon pea species can be used to increase vegetation coverage in other regions where other species failed (Hanke *et al.*, 2013).

CONCLUSIONS

The approach presented in this study, beyond its versatility (integrating women's, men's, youth, technicians', researchers' and small and large farmers' opinions) has the potential to bring together multiple actors involved in the management and use of natural resources and to highlight their knowledge and experiences in order to assess, identify and test sustainable soil and water management practices. Stakeholders were consistently and actively involved in all steps, from spreading the word about the project to the monitoring and evaluation, collecting and mapping desertification indicators and selecting and implementing test options. According to stakeholders, the relevance of this approach lies in that it provides an opportunity for each group of actors to speak clearly and openly in discussions and be part of the project. Implementing the actions has not only helped resolve conflicts between farmers and cattle raisers in some areas of the basin but also to diversify farmers' yields and reduce the topsoil erosion by limiting the farmers' conventional weeding practices, improving soil vegetation and mulching cover, and sediment trapping.

However, this approach requires a well-trained team of moderators and facilitators and a multidisciplinary field team. It raises expectations among farmers and unfortunately financial resources available limit beneficiary numbers. The step-by-step approach applied in this paper is easy to replicate and adapt and represents a powerful dynamic tool to facilitate joint decision-making processes among stakeholder groups implicated in the use and the management of natural resources.

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