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Research article

Financial incentives: Possible options for sustainable rangeland management?

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ABSTRACT

Large-scale mismanagement of natural resources emanating from lack of appropriate policies and regulatory framework is arguably one of the reasons that led to resource degradation and poor livelihoods in many countries in the Middle East and North Africa (MENA) region. Sustainable rangeland management practices (SRMPs) are considered to be a solution to feed shortages and rangeland degradation. However, the scope for SRMP adoption, has been a subject of debate. Using a case study from Syria and the application of the Minimum Data Analysis method (TOA-MD), this paper provides empirical evidence for ensuring wider adoption of SRMP. The paper argues that the introduction of financial incentives in the form of payments for agricultural-environmental services can increase the economic viability and enhance the adoption of SRMPs and is a better alternative to the unsustainable state subsidies for fodder purchases and barley cultivation on rangelands. Model results indicate that further investment in research toward generating low cost technologies and tailored governance strategies including a financial incentive system would lead to better management of rangelands and improve livelihoods in the Syrian *Badia*. These findings are valuable for policy makers, donors as well as development and extension practitioners in the MENA region as they can better inform future courses of actions.

1. Introduction

Rangelands cover more than 40% of the earth's surface and two-thirds of the global dryland area (UNCCD et al., 2009). Rangelands are both the primary sources of food and feed for livestock production and of fuel-wood and medicinal herbs for millions of resource-poor pastoral and agro-pastoral communities (Louhaichi et al., 2009). Rangelands also provide an important habitat for diverse plant and animal species (Trumper et al., 2008).

An over-riding feature of rangeland is their low, but highly variable, precipitation. In the face of growing animal and human population pressure, poor management practices, and climate change, the ecological health of rangelands is in a precarious condition (Han et al., 2008). The increased competition between cereal production and grazing in low rainfall areas is a further threat to the traditional nomadic system of drought management and contributes to the degradation of rangelands (Hazell et al., 2001). Thomas (2008) defines rangeland degradation as long-term loss of ecosystem function and productive capacity of rangelands, which manifests in the reduction of and damage to biophysical, social, cultural, or economic features (Thomas, 2008).

To encourage domestic production of livestock, many governments in the dry areas provide highly subsidized forage to livestock owners. However, these subsidies encourage overstocking and over grazing and thus are indirectly financing desertification by reducing herders' incentives to adapt herd sizes to forage availability and by encouraging other unsustainable land use practices such as barley cultivation (Baas et al., 2000; Hazell et al., 2001). Other institutional and management approaches aimed at addressing rangeland degradation have been tested in the dry areas of MENA but their adoption has been limited – adding to the frustrations of governments and development agencies alike (Dutilly-Diane et al., 2007).

Over the years, payments for environmental services (PES) and

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voluntary agri-environmental schemes have gained momentum as effective instruments to provide incentives for sustainable management of ecosystems. Due to their exorbitant costs often related to high transaction costs (Dunn, 2010), PES agri-environment schemes frequently emerge as options for high-income countries only (Donald et al., 2006; Primdahl et al., 2010). However, the adoption of PES has begun to increase in many developing countries in recent years (e.g. Dunn, 2010; Fripp, 2014; Codato, 2015). When compared to the costly state subsidies for fodder in the MENA region, PES are becoming a more realistic management alternative. There is now a strong case in favor of replacing state subsidies with agri-environmental schemes that serve the dual purposes of providing more fodder and enhancing the sustainable management of rangelands (Woertz, 2013).

Using a case study from Syria and the Minimum Data Analysis method (TOA-MD) support this emerging trend and provides empirical evidence regarding incentive payments and the optimal amount needed to ensure different adoption levels of SRMP. This paper thus supports policy and donor decisions that aim at enhancing the sustainable management of rangelands. The results of this study will also be useful for development and extension practitioners in guiding and increasing the efficacy of future interventions for sustainable rangeland management in the dry areas of the world in general and the MENA region in particular.

2. Description of rangeland management practices in the study area

2.1. Description of the study area

The case study was conducted in the lowlands of the Syrian *Badia* (an Arabic term for steppe), (34°28′45″N and 38°35′00″E). The Syrian Ministry of Agriculture and Agrarian Reform (MAAR) defines the *Badia* (zone 5) as the driest agricultural zone in Syria – with a Mediterranean arid climate, exhibiting highly variable and extreme low precipitation and temperature patterns. Average long-term annual precipitation is approximately 180 mm, with average, minimum and maximum annual temperatures of 17.6 °C, 2.4 °C and 39 °C respectively. The *Badia* comprises of 10.2 million ha (55% of the country's total area of 18.5 million ha) and is the most degraded ecosystem in Syria.

The Syrian *Badia* is residence for more than one million nomadic and transhumant *Bedouins* Population density stands at about 0.1 persons per ha. Eighty-eight per cent of the active workforce in the *Badia* engages in herding. However, about one third of the households have small herds leaving the pastoralists largely under-employed. The *Badia* inhabitants have very limited off-farm employment opportunities, which leads to impoverished livelihoods. Nonetheless, the pastoral communities in Syria are important because they are virtually self-sufficient in terms of daily food and they supply the urban areas with a great part of their animal products (Masri, 2006). The rangelands carry approximately 12 million animals (about 10 million sheep, 1.7 million goats and 27 thousand camels) that provide about 15 percent of the nutritional requirements for sheep in Syria in a "normal" rainfall year (Vercueil, 2003). Livestock rearing is the main economic activity in the Syrian *Badia*, making it the largest farming system (by size) in the country (Wattenbach, 2006). Barley grain supplement is used for a period of about 90 days during winter. During the summer, the animals from the *Badia* migrate to graze on agricultural residues after harvest in the higher rainfall zones in the west of the country where wheat, barley and cotton are grown.

From the legal point of view, the *Badia* is state-owned land. It is characterized by hilly, infertile lowlands that harvest scarce rainwater and accumulate soil and nutrient deposits throughout the soil profile. Water is the main limiting factor for both crop and livestock production. Ground water tables are typically very deep (over 150 m) thus making the use of ground water for agriculture and land management technically and economically infeasible. Earth dams and water ponds are the only means of trapping and holding water from seasonal rainfall and streams in the area, and a number of dams and water harvesting structures have been constructed since 1997 (IFAD, 2012).

2.2. Management of the Syrian Badia

Bedouins cultivate barley in the *Badia* lowlands because of their fertile soils and high soil moisture levels. Unlike the practice in more favorable areas, however, barley is cultivated in the *Badia* lowlands every year without crop rotation (Sadiddin and Atiya, 2009). Barley is grown as a multipurpose crop that can be harvested as a grain or straw, and grazed as stubble post-harvest (Thomson, 1985). During drought years, or when crops do not achieve complete maturity, barley is also grazed during the green or mature stage. During wet seasons, barley is grazed before harvesting and also used for human consumption and malting (Mustafa et al., 2006). Land preparation for barley cultivation is done using poly-disk plows which removes perennial and annual vegetation and so stimulates wind and water erosions, depletes the remaining soil seed stock, and uplifts the "dead soil" containing sterile carbonates. The result is a crusted soil that prevents water infiltration and promotes further land degradation (Gintzburger et al., 2006).

A further negative side effect of barley cultivation is that herders become tied to one location during cultivation and harvesting, with livestock feeding effectively tethered to cereal stubble during summer grazing (Louhaichi and Tastad, 2010). Such reduction and containment of traditional nomadic herding practices of the *Bedouin* leads to concentrated rangeland degradation and, in sum, indicates that the extensive and increasing cultivation of barley in the steppe (Sanlaville, 2000) is an important aspect of the mismanagement of the Syrian *Badia*.

As a measure of combating rangeland degradation, the Syrian Government has banned barley cultivation in the *Badia* since 1995 – a measure that is unique throughout the MENA region. The government had to deal with the tradeoffs between the two competing objectives of supporting extensive livestock production in order to meet the ever-increasing demand for red meat and controlling livestock production because of rangeland degradation. Banning barley cultivation in the *Badia* was a measure that recognized the damaging effects of cereal cultivation on the highly fragile soils and natural vegetation in these environments (Edward-Jones, 2003). However, a more holistic concept of rangeland management and rangeland governance was missing and, due to the absence of viable alternatives for livestock feeding, *Bedouins* still illegally cultivate barley, especially in the lowlands.

Recognizing the need to rehabilitate the severely degraded rangelands and re-establish fodder production, the government initiated the Badia Rangelands Development Project (BRDP). This project restored about three million ha of the *Badia* rangelands (IFAD, 2010). The project provided all the needed inputs (e.g., seedlings, tractors, and irrigation) while the communities participated physically in implementing the project activities while being remunerated for their daily labor. This set-up gave the *Bedouins* a sense of ownership as they played a key role in a successful project.

2.2.1. Options for sustainable management of rangelands

Prior to project implementation, the common rangeland management practice was continuous grazing leading to low vegetative cover, dominance of invasive species and soil crusting. In this study, three SRMPs were recommended to the *Bedouins* as optional management alternatives to the current system. The three SRMPs are: periodic resting, direct seeding or broadcast seeding, and shrub transplantation. These SRMPs increase rangeland productivity while simultaneously decreasing rangeland degradation. The new options ensure that natural vegetation, emerging seeds and transplanted shrub seedlings receive adequate time to recover and/or become established between grazing intervals, by herding the livestock to a different area for grazing. Furthermore, the choice of plant materials (seeds for broadcasting or shrub seedlings) are native species which are well adapted to the agro-ecological conditions of the agro-ecosystem. The three SRMPs were the basis for the *ex-ante* TOA-MD analysis, by comparing and analyzing which management practices would be more likely to be adopted (and to what extent combined) according to the amount of a compensation payment. These practices were at the same time introduced by the BRDP project, so the *Bedouins* interviewed were aware of the benefits of these SRMPs and could see the effects on the ground.

2.2.1.1. Periodic resting. The first method to improve degraded lowland rangelands was protection from continuous grazing so as to provide the natural vegetation with the opportunity for self-recovery. The protected area was opened for grazing after two years, followed by controlled grazing twice per year. The dry matter biomass in protected lowland areas is as high as 2344 kg of dry matter per hectare (DM/ha) (Louhaichi et al., 2012). This is the least costly alternative to recover the rangeland (even after including the opportunity cost of production and the cost of forgone production). Though this alternative is the cheapest and slowest to reach desired goal, it does lead to site restoration.

2.2.1.2. Direct seeding or broadcasting. The second method was direct seeding or broadcasting seeds. The only equipment needed for this method was a tractor that makes shallow scarification of the soil before broadcasting. This method considerably reduced the establishment cost of shrub species. The cost of direct seeding was only one-tenth of that of shrub seedlings transplanting (Osman et al., 2006), and its implementation was only 6% of the improved rangeland establishment cost (Table 1). The risk of direct seeding is its dependence on rainfall to encourage germination and whether the rangeland is protected from grazing for a sufficient period, before the rehabilitated land can be used for grazing. Nevertheless, direct seeding lead to an average DM yield for shrubs of about 550 kg DM/ha in autumn and 65 kg DM/ha in spring, and inter-space vegetation biomass of 2344 kg DM/ha – equivalent to that of periodic resting, which adds up to 2944 kg DM/ha.

2.2.1.3. Shrub transplantation. Shrub transplantation involved growing shrub seedlings in a nursery and transplanting them into deep ripped furrows in flat areas or contour lines for sloping land. The main cost items in shrub transplantation were the cost of seedling production followed by irrigation and associated labor cost (Table 2). Depending on the season of transplantation, only one or two rounds of irrigation were necessary during the establishment phase. Once the rangeland was rehabilitated, rational grazing and minimum maintenance were the only operational costs. In previous and on-going development projects, the survival rate of transplanted shrub seedlings has exceeded 90%. One should note that this SRMP is the most expensive rehabilitation measure compared to the other options. Nonetheless, most rangeland rehabilitation projects in the MENA region choose this practice as it leads to the highest biomass productivity in a short time.

Table 1
Establishment cost for 1 ha of improved rangeland by direct seeding.

Costs	Quantity	Price (SYP/ha)[a]	Costs (SYP)
Seed rate (kg/ha)	7	64.6	452
Tractor	1	50.0	50
Labor		15.0	15
Protection		336.0	336
Total			853[b]

[a] For direct seeding, different shrub seeds are equally mixed: *Salsola vermiculata*, *Atriplex leucoclada*, *A. halimus*, *A. canescens*, and *Haloxylon persicum*. The unit price is the arithmetic mean of the unit prices of these shrubs.
[b] Equivalent to ~US$19.
Source: Unpublished data from BRDP (2010)

3. Methods

The biophysical and ecological benefits of the SRMPs of shrub transplanting, direct seeding, and periodic resting are well documented in the literature (Louhaichi et al., 2012, 2014; Minnick and Alward, 2012). However, the literature regarding their economic benefits as well as their potential for adoption, especially in the dry areas of the MENA region, is scanty. This paper uses the TOA-MD approach (Antle and Valdivia, 2006) for an *ex-ante* analysis of the economic returns and the potential for adoption of SRMP in the Syrian *Badia*. The TOA-MD approach has already been used in a number of studies which analyze the economic viability of the introduction of different new technologies or practices and the role of PES in enhancing their adoption (Adiku et al., 2015; Rao et al., 2015; Homann-Kee Tui et al., 2014, Ilukor et al., 2014; Antle et al., 2010; Torero et al., 2010; Claessens et al., 2009).

Analysis using TOA-MD is based on comparing benefits and costs, where decision makers are assumed to choose among alternative SRMPs based purely on the superiority in their net returns. While this is true of virtually all economic analysis based on an economic rationality assumption, the TOA-MD is unique in that the analysis of choices is performed for a population of farms. Thus, it is based on the parsimonious characterization of the distribution of returns in the population (Antle and Valdivia, 2006) where it is designed to take into account spatial heterogeneity within the population (Claessens et al., 2009).

Despite the lower level of accuracy compared to more rigorous and more complex mathematical programming and simulation models, the difficulty of quantifying the magnitudes of a large number of sources of uncertainty give the TOA-MD approach a considerable advantage. Its timeliness, low cost of implementation, and its simplicity and transparency make it an attractive method to apply in data-scarce contexts (Antle and Valdivia, 2006). By making an assumption about the distribution of the opportunity cost of adoption for each stratum of the population (as defined by the

Table 2
Investment cost for improved rangeland with shrub transplantation.

Costs	Quantity	Cost (SYP)
Nursery cost for seedlings	450 seedlings	4050
Labor cost for planting	10 person-hours	3500[a]
Cost of equipment for planting		3000
Irrigation	2 times	3000–3500[b]
Protection		336[c]
Maintenance	Negligible	
Total		17,750–18,250[d]

[a] Calculated from the monthly salary of a worker.
[b] Irrigation costs vary slightly according to rainfall.
[c] For an area of 500 ha usually two guards are hired throughout a year, with monthly salary of 7000 SYP.
[d] Approximately US$300–313/ha.
Source: Unpublished data from BRDP (2010)

analyst), the TOA-MD model generates predictions of adoption under different scenarios. TOA-MD is well suited to address the uncertainty in potential adoption or impact assessments where sensitivity analysis explores how results change with different assumptions.

Agent-based models and household models using mathematical programing and stochastic dynamic programing would have been the models of choice for this analysis. Such models would be able to capture the interactions between agents, the risk behavior and optimization by *Bedouin* households in the face of the stochastic nature of production and the dynamic decision making process needed in response to farming and the evolution of the natural resource (particularly soil properties) over time. However, given the limited data available for this study and the merits listed above, the TOA-MD model is selected as an option of last resort for this analysis.

There is a large body of literature on factors affecting the adoption of new agricultural technologies or practices. Most of these studies identified farmer and farm characteristics, awareness about the new technologies, and access to information, seed, extension services and credit as important determinants of adoption (Shiferaw et al., 2008; Vitale et al., 2011; Baumgart-Getz et al., 2012; El-Shater et al., 2016). All these studies assume the economic superiority of the new technologies/practices over traditional practices, which may not always be true as well as easily adopted. However, in this particular case, the validity of the use of the TOA-MD model, with the underlying assumption of economic rationale as the only decision criteria for adoption, can be justified on various grounds. 1) The BRDP project, which introduced the SRMPs, has been working on the ground for over 10 years during which these practices were popularized among all the project communities using large scale demonstration trials, field days and community meetings. Therefore, all *Bedouins* were familiar with and have first-hand experience on the SRMPs thereby reducing the information gap among farmers. 2) The *Bedouins* are highly mobile in response to rain events and the *Badia* is a highly degraded land with little vegetative cover. Therefore, there is small (if at all) variability in terms of land characteristics, farmers' access to credit and extension services. 3) More importantly, the *Bedouins'* preference of the SRMP over the continuous grazing has already been established where all of the community members were enjoying the benefits over the project's lifetime.

Supply, and hence market prices of forage, depend heavily on the annual climatic conditions and season of the year, and have huge implications and importance for herders' production and marketing decisions. While seasonal price variations are important, the pastoral communities in the *Badia* often play a passive role – being price takers as net-buyers of animal feed with no alternative source of feed. Therefore, this analysis ignores seasonal price variations.

Suppose that:

- t represents the time period (t = 1 is first year, t = 2 is second year, …., t = T is the period after T years from the start);
- s represents the state of nature under consideration defined mainly based on farmers' perceptions on the levels of precipitation (s = 1 is a bad year, t = 2 is an average year, and t = 3 is a good year);
- i represents a single farmer i;
- p_{ts} represents output price levels in year t and state of nature s;
- h represents the different rangeland management practices (RMP) where $h = 1$ represents the current practices of open grazing and barley cultivation; and h = 2–4 represent the adoption of the new sustainable rangeland management practices, where h = 2 represents shrub transplantation, h = 3 represents shrub direct seeding, and h = 4 represents resting
- y_{ihts} = yield obtained by farmer i using SRMP of h in period t and state of nature s;
- c_{iht} = total production cost of farmer i using SRMP of h in state of nature s (note here that the subscript s is not used because production costs are assumed to be the same across all states of nature as the main costs are incurred at planting before the realization of weather);
- v_{ihts} represents net returns per hectare for farmer i using SRMP of h in period t and state of nature s note that = v_{ihts} is a function of p_{ts}, y_{ihts}, and c_{iht} (i.e., $v_{ihts} = v_{ihts}(p_{ts}, y_{ihts}, c_{iht})$

Given the climatic risks with the different states of nature s, the expected value (in dollars per hectare) of discounted net returns for farmer i using the SRMP h over T time periods is given by:

$$E(V_{ih}) = \sum_{t=1}^{T} \sum_{s=1}^{S} \delta_t [prob_s * v_{ihts}(P_{ts}, y_{ihts}, c_{iht})] \quad (1)$$

where:

- $\delta_t$represents the annual discount factor which is given by $\delta_t = 1/(1+r)$,
- r is the discount rate (assumed to be constant across years), and
- $prob_s$ = the probability of state of nature *s where probability of bad, average and good states of nature respectively are* $prob_1 =) = 0.48$; $prob_2 = 0.35$; and $prob_3 = 0.17$. These probabilities were obtained from the survey, which solicited Bedouins' perceptions concerning the distribution of rainfall across years.

$$v_{ihts}(P_{ts}, y_{ihts}) = p_{ts} * y_{ihts} - c_{iht} \quad (2)$$

Even though the cost of production c_{iht} is assumed constant across different states of nature s, it varies across years (especially for shrub production, which occurs across many years), and can be expressed as follows:

$$c_{iht} = \nu c_{iht} \mp F_h \quad (3)$$

where νc_{iht} is variable cost which is proportional to the amounts of inputs used in production by farmer i in period t using production system h and F_h is a fixed (one-time) cost which takes the value of zero for $h = 1$, because the fixed costs under the current production system are considered as sunk costs; and it takes the value equal to the fixed cost of adopting the new production system for $h = 2$, or 3, or 4.

Supposing the opportunity cost of technology h for farmer i is given by w_{ih}, then the expected opportunity cost of adopting the new production system (of for example h = 2) on one hectare of land can be computed as:

$$W_{i2} = E(w_{i2}) = E(V_{i1}) - E(V_{i2}) \quad (4)$$

where, $w_{ih} = v_{ih} - FB_{ih}$

Where FB_{i1} is the sum of forgone benefits resulting from the decision to continue using the old practice and FB_{i2} is the sum of forgone benefits resulting from the decision to adopt the new SRMP (of say shrub transplanting).

Based on this formulation, farmer i adopts the SRMP if and only if $W_{i2} < 0$. Otherwise, he/she continues to use only the traditional rangeland management practices (TRMPs).

If the social (and environmental) benefits of the SRMP exceed their private benefits, and the private benefit of the TRMP is higher than the SRMP, then incentivizing farmers with some form of payment may encourage adoption of the new SRMP. As discussed in the introduction, this approach alternatively called “PES” or “payments for agri-environmental services” is gaining momentum in the literature as an effective way of enhancing ecologically friendly and sustainable management of natural resources and the environment. In this framework, farmers are compensated for the services they provide by adopting environmentally friendly production practices (Ferraro and Kiss, 2007; Lipper et al., 2010). In this paper, given the opportunity cost of adopting the new technology options W_{i2}, we evaluate the effect of such payments and attempt to determine the minimum incentive payment g (in dollars/ha[1]) that will ensure the desired individual adoption rate $R^{*}(g)$ for the different SRMP.

The opportunity cost of adopting the SRMPs varies from one site to another. Assuming that the spatial distribution of the opportunity cost of adoption follows a normal distribution with a density function $\phi(w)$, the adoption rate R of the SRMP can be calculated by ordering the various w_i for given prices p. Thus, R of the SRMP in the population with incentive level of g can be calculated as:

$$R(g) = \int_{-\infty}^{W+g} \phi(w)\mathrm{d}w \tag{5}$$

$R(0)$ represents the adoption rate with no incentive payments. With an incentive payment level of g, the decision to adopt or not will be based on whether $W_{i2} - g \geq 0$ (i.e., SRMP is at least as profitable as TRMP for farmer i even with the incentive payment for adopting the new production system) or $W_{i2} - g < 0$, implying that the SRMP is more profitable than the TRMP when considering the incentive. Assuming that c_1 and c_2 are constants, and given the identity in Equation (3), it follows that:

$$\sigma_w^2 = \sigma_1^2 + \sigma_2^2 - 2\sigma_{12} \tag{6}$$

where the spatial heterogeneity of yield from the TRMP (σ_1^2) is observable.

The recommended shrubs species under the new SRMP were chosen for their specific qualities of drought tolerance and yield variability reduction. Hence, they are expected to increase farmers' resilience to weather and climate change variability. However, data on yield variability due to soil and weather conditions and hence spatial heterogeneity associated with the SRMP (σ_2^2) and the spatial correlation between returns to alternative practices (σ_{12}^2) are not available. Hence, for the purpose of this analysis, we assume that each of the SRMP does not have any impact on yield variability, i.e., $\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \sigma_4^2 \equiv \sigma^2$ and there is no spatial correlation between the returns to the two alternative production systems ($\sigma_{1i} = 0$ for i = 2, 3, and 4). By making these assumptions, we are making the variance of net returns to the new production system (σ_i^2 for i = 2, 3, and 4) high. With these assumptions which in effect ignore some of the most important benefits of the SRMP, the model will underestimate the potential adoption rates. Thus, the estimated net returns and adoption figures obtained from our model results will represent the minimum net returns and adoption levels that can be expected under different PES scenarios.

Depending on the technologies chosen, rehabilitation of degraded rangelands needs at least 2–3 years for establishment before being opened for grazing. Hence, a reasonable assessment of the economic viability of such interventions can be done only in the long term. Therefore, this study assumes that the decision to adopt SRMP is based on the relative size of the NPV of the sum of net returns from the different SRMP available to the farmer over 10 years.

To compare forage production (biomass) from the different SRMP, every unit of fodder shrub is converted to a feed unit that is equivalent to barley. A number of feed evaluation systems have been developed over the years. In this study the Scandinavian feed unit (Sundstøl, 1993), which equals to 1 kg barley as a feed unit is used. To convert 1 kg of DM yield into barley grain equivalent, we use the feeding value of *Atriplex* species, which is estimated at 0.35 kg feed units per kg of DM (Shideed et al., 2005) as a coefficient. Hence, the DM yield of an improved lowland rangeland site is approximately 1750 kg/ha, 900 kg/ha, and 780 kg/ha barley grain per year in good, average, and bad years, respectively. Then, the market price of barley is used to calculate the corresponding economic value of biomass production from rangelands.

4. Data

Data from a random sample of 25 communities from two districts within the Aleppo Province of Syria was used for the ex-ante assessment of the adoption potential of SRMP, popularized among the *Bedouins* by the BRDP project. This enabled the *Bedouins* to evaluate interest in and possible adoption of these practices by taking into account the circumstances governing their livelihoods, property rights and alternative land use practices.

The study focused *Bedouin* communities having in total just under 6000 people and living in representative lowland *Badia* environments. It is asserted, therefore, that although the demographic and geographic parameters for the study are limited, they are sufficient to provide useful and reliable insights into herder land management practices, perceptions of those practices and the environmental factors that influence those practices.

The data from the 25 communities were collected using a structured survey questionnaire administered in focus group discussions in 2010. In each community, 6–10 *Bedouin* household heads were invited to a meeting where the questions were asked by the enumerator and answers were provided after a discussion by all respondents. When multiple answers were received from respondents the enumerator would ask all those present to discuss and take notes on the discussion in order to identify and analyze the reasons for the different perceptions. Data collected included demography for the typical household in each community, subjective characterization of the biophysical conditions of the natural resources and past and current land use dynamics. *Bedouins*' perceptions about drought years and good years, seasonal and annual rainfall fluctuations, rangeland degradation and rangeland rehabilitation, as well as yield and cost of barley production were also collected. The cost of adopting and using the SRMP was collected from the BRDP project.

To ensure common understanding of the different weather classifications among all participants in the focus group discussions, a good year was defined as one with sufficient rain (over 250 mm) for farmers to graze their livestock on green-stage barley and still be able to harvest barley grain later during the season. An average year was defined as one for which rainfall was medium (between 180 and 250 mm), where barley grain yield was low and no green-stage grazing was possible earlier in the season. Drought or bad years were those during which rainfall was very low (less than 180 mm) and farmers could at best expect a minimal amount of matured barley crops for grazing their livestock later in the season, or otherwise would expect a total loss.

The use of *Bedouins*' perceptions is an important aspect of this paper, as their decisions including technology adoption are mainly determined by what they perceive and not necessarily by facts of

[1] The distribution of the opportunity cost will shift to g.

weather or technological considerations (Adesina and Baidu-Forson, 1995; Wubeneh and Sanders, 2006). *Bedouins'* perceptions were compared to available scientific data and the reasons for deviations were analyzed.

A total of 5780 inhabitants live in the 25 communities selected for study. The minimum, average and maximum number of inhabitants per community is 170, 635, and 1255 respectively. The total land area of lowlands occupied by the communities is about 1808 ha, of which 590 ha (32%) is cultivated with barley. Survey results show that each community has lowlands that are partly used by herders for grazing and partly for barley cultivation. The selected sample communities cultivate 17–32% of their lowlands. The large difference in proportions of cultivated area is due to the landscape features of each lowlands, as these are formed naturally over long periods.

The soils in all 25 communities are homogenous and key informants describe them as about 15 cm deep with surroundings of gentle slopes in the range of 5–10°. Moreover, 76% of the informants describe the soils as having high moisture while 92% describe them as fertile and rich in organic material. Fourteen of the pastoral communities (over 50%) believe that there is severe degradation and serious overgrazing in lowland sites of the community; nine (36%) think it is only moderately degraded, and the remaining two (8%) believe that their pastures are protected. Concerning the main causes of lowland degradation, 16 communities (64%) think that recurrent droughts in recent years had very high influences. As for the causes of low seed germination, seven communities (28%) think that a lack of alternative grazing is an important factor and six (24%) believe that crusting of the soil surface is a factor for non-cultivation of some areas.

According to the perceptions of the herders, the chances of good, average, and bad years are 17%, 35%, and 48%, respectively (Table 3). The interviewed *Bedouin* communities think that rainfall is too low for crops to grow in the *Badia* in nine out of 10 years. Science concurs with this view, estimating the occurrence of years in which the rainfall is too low (less than 150 mm) for cropping is nine out of 10 in areas (Sanlaville, 2000). Since 2005 the annual precipitation in the Syrian *Badia* has only exceeded 150 mm in 2009 and then by just 10 mm (Fig. 1).

A comparison between the actual rainfall data from the *Badia* for the years 1996–2010 (Fig. 1) and the perceptions of the *Bedouins* reveals that the Bedouins have an accurate understanding of the distribution of rainfall. Their estimates of probabilities of good and average weather years were underestimated by only three and eight percentage points, while that of bad was overestimated by about six percentage points. During 2005–2010, the annual rainfall was below the long-term average annual precipitation of 180 mm, confirming the herders' necessity to sell their herds and migrate to

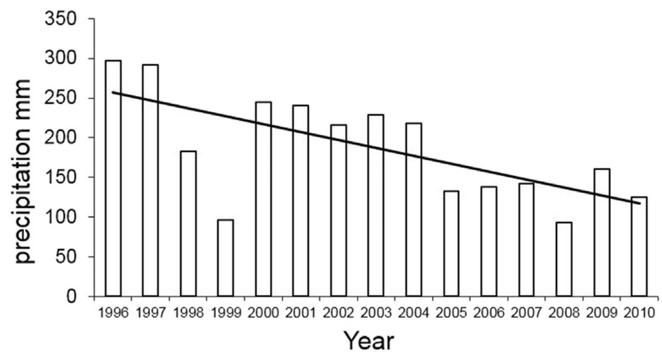

Fig. 1. Annual precipitation at Maragha, North Syria, during 1996–2010.

urban areas during this period. The *Bedouins* indicate that before 2005, they had to sell their herds because of "climate change" and "degradation" of the *Badia* – indicating a strong subjective appreciation of environmental degradation of the *Badia* over the last 10 years. During the focus group discussions, the participants expressed that in the last 10 years many *Bedouins* were forced to sell their entire herd and move to urban areas to find alternative livelihood opportunities because of drought. In the study communities, the average herd size decreased from 448 (15 years ago), to 208 (5 years ago) (Table 3). The *Bedouins* clearly described the extremely negative effects of the drought years and the consequences of greater rangeland degradation. Among the 25 sample communities, only two communities received monthly income from the government, while the remainder did not have off-farm employment opportunities and hence, no other sources of income. The fact that the large majority of the *Bedouins* do not have other household income sources than agro-pastoralism illustrates how fragile their situation became after several drought years and how much this increased livelihoods risks.

In the interviewed communities, barley is cultivated in the lowland every year without rotation. All agricultural operations for barley production are mechanized, however, fertilizer is not used and paid labor is uncommon. In most cases, the cost for seed transportation is about 2% of the total production cost. In bad years, *Bedouins* often lose the entire crop and only get some green barley for livestock grazing in very good years. In average and good years, farmers harvest barley as well as straw. They also graze or rent barley stubble for grazing, the revenue from which varies greatly from one farmer to another. Any financial advantage is however off set by additional harvesting costs that include rental of combine harvesters and grain bags. Harvesting costs are nearly half of the entire barley production costs (Table 4).

Given the exceptional water harvesting capacity of lowlands, barley yields in the lowlands are often higher than rain-fed cultivation in the *Badia* and can be compared with irrigated cultivation yields in certain cases. For example, an average seeding rate of 126 kg/ha, grain yields in the good years can reach up to 4000 kg/ha, with an average of about 1500 kg/ha. In average years, however, the average yield is about 721 kg/ha. Data from experimental stations and surveys show that the average yield for cultivated barley without rotation and fertilization in the *Badia* is 450 kg/ha with 920 kg straw/ha and 570 kg/ha on the frontier of the *Badia* in Aleppo Province (Thomson, 1985). The national average yield of barley is around 680 kg/ha (Sadiddin and Atiya, 2009). Nevertheless, Mustafa et al. (2006) reported yields as high as 5000 kg/ha on fertile land and up to 1500 kg/ha in the driest areas in very good seasons.

During the survey for this research it became clear that the *Bedouins* have very limited access to official credit. This limitation

Table 3
Pastoral communities' characteristics.

	Average	Min.	Max.
Age	55	30	89
Family size	9	4	14
Number of sheep	115	10	400
Number of sheep 15 years ago	448	75	1200
Number of sheep 5 years ago	208	60	800
Perceived number of good seasons in 10 years[a]	1.7	1	3
Perceived number of average seasons in 10 years[a]	3.5	1	6
Perceived number of bad seasons in 10 years[a]	4.8	2	8
Number of lowlands in the sample	79		
Number of lowlands cultivated prior to cultivation ban	72		
Number of lowlands cultivated this year	50		

[a] Averages for all 25 pastoral communities.
Source: Survey 2010

Table 4
Barley production data.

Production input/output	Unit	Average	Std. dev.	Min	Max
Total area of lowlands	ha	72	60	10	250
Cultivated lowlands	ha	24	11	10	77
Seed rate	kg/ha	126	23	100	200
Cost without harvesting	SYP/ha	1580	515	1037	2463
Cost with harvesting	SYP/ha	3016	378	2207	4060
Barley grain yield (good year)	kg/ha	1492	1140	240	4000
Barley grain yield (average year)	kg/ha	721	854	0	3000
Barley straw yield (good year)	kg/ha	583			
Barley straw yield (average year)	kg/ha	397			
Barley price (good year)	SYP/kg	10	1	8	13
Barley price (average year)	SYP/kg	11	0.5	10	13
Barley price (drought year)	SYP/kg	15	4	11	22
Stubble (straw) grazing, barley[a]	SYP/ha	2500–3000			
Stubble (barley) grazing, average year[b]	SYP/ha	2000			

[a] Grazing is before harvesting.
[b] Grazing is after harvesting.
Source: Survey 2010; 1 SYP = US$0.02.

means that as the *Badia* is state owned land the ability of the *Bedouin* to use it as collateral is equally limited. The land tenure also means that any financial incentives from government that may relate to land management and land use are not perceived to have particular economic benefit – this is one further reason why *Bedouins* do not adopt SRMPs but prefer barley cultivation. Instead famers establish partnerships with financers (or investors or lenders) in the city who can fund barley cultivation on the fertile lowlands. In these financial arrangements production risks are either shared with or at times borne by the investor. As a result, *Bedouins* are inclined to cultivate barley even if, in most cases, they sustain a total loss due to bad weather. Such arrangements between *Bedouins* and financiers have become common and have existed for a long time and indicate that barley cultivation bans have had minimal impact on the amount of crop cultivation in the lowlands (Table 3). Before the ban, for example, 72 out of 79 lowlands of the sample were cultivated and, after the ban, 50 were still cultivated. The full extent of *Bedouins* preference for barley cultivation became clear after the civil unrest in 2011. After that time the *Bedouins*' thought the Syrian Government had lost control over the *Badia* and thus could no longer enforce the barley cultivation ban. During the research visits to the *Badia* in 2012, it became clear that, the *Badia* had been to a large extend distributed by the *Bedouins* into individual marked fields for barley cultivation. An analysis of *Bedouins*' strong preference for barley cultivation shows also that traditional rangeland governance which gall under SRMPs are still known by the *Bedouins* but no longer practiced as they feel that the ownership of the *Badia* belongs to the government and not to themselves.

5. Results and discussion

5.1. Potential for the adoption of sustainable rangeland management practices

This section presents the TOA-MD model results. The potentials for the adoption of the three SRMPs under different levels of incentive payments are analyzed.

5.1.1. Net present value (NPV)

Open grazing and barley cultivation dominate current land use. This study therefore compares the profitability of the three new methods (shrub transplantation, direct seeding, and temporary resting or controlled grazing) for improving productivity of degraded lowlands relative to the status quo (i.e., open grazing and barley cultivation). We assume that the establishment cost of improved rangeland is a suitable proxy for the fixed one-time cost of adopting the new production system that has to be incurred upfront. The only fixed cost of adoption of the new technologies is the cost of supplementary feeding during the first two years before the shrubs are well established. Barley yield in the sample is highly dispersed around its mean with coefficient of variation (CV) of 0.7–1.11, whereas CVs of shrub yield in the different villages were in the range of 0.12–0.18.

Given the long period needed for full rehabilitation of rangelands, a farmer's decision to adopt the new agricultural practices is regarded as a long-term investment decision. Hence, discount rates are used to compute the NPVs of the streams of costs and incomes. The discount rate for Syria for the period prior to 2010 was 5% (IES, 2010). The interest rate on time deposits in the country during the study period was in the range of 6–10% (Central Bank of Syria, 2010). Given that the decision makers in the present study are resource-poor *Bedouin* herders who are used to a very mobile life style and, hence, likely have a strong preference for the present with limited access to credit facilities, the upper limit of the range for interest rates (10%) is used in this study for discounting. However, to see the effect of discount rate on adoption decisions, simulations are also made using a discount rate of 5% and the results are consistent with only slight shift of the curves to the right.

The expected NPVs of revenues and costs of different RMPs are used for estimation of the adoption rates for the different practices. Even though open grazing has no cost, it is the practice with the least NPV of net returns (Table 5). Given the NPV of the expected net returns, the economically optimal adoption rates of the SRMP of transplantation, broadcasting, and resting are 10, 50, and 20%, respectively. However, compared to barley cultivation, the difference in the NPVs for the other practices are less than that of open grazing.

The minimum incentive payment denoted in the model by g (measured in SYP/ha) is computed in this study as the difference between the rates of returns of the two competing RMPs. This amount can be understood as the minimum amount of payment that farmers should be paid in order to make them equivalent to the traditional practice (particularly barley cultivation) and the SRMPs. Improved rangeland provides several environmental services such as carbon sequestration, *in situ* conservation of biodiversity, reduced wind erosion, higher water productivity and flood erosion control (Dutilly-Diane et al., 2006). Therefore, the minimum incentive payment represents the level of payment that needs to be paid to encourage the farmers to adopt the environmentally sustainable production systems.

Table 5
Average net present values (NPVs) of costs and revenues.

Production systems	Open grazing	Barley cultivation	Shrub plantation	Reseeding	Resting
NPV of expected revenue	18,639	63,398	64,547	64,808	51,885
NPV of expected cost[a]	0	16,505	25,000	11,788	9114
NPV of expected net return	18,639	46,894	39,547	53,020	42,771

[a] NPVs of expected cost are calculated for the shrub transplantation, reseeding, and resting after adding the value of barley yield lost for two years until the seedlings establish well.
Source: Authors' calculation from survey data 2010.

Model results show that financial incentives lead to higher adoption of the three tested SRMPs: shrub transplantation, direct seeding, and periodical resting (Fig. 2). In Fig. 2, the left extreme curve represents the possible adoption levels for the SRMP of transplantation under different PES scenarios. For instance, an incentive payment of only about 1000 SYP (or US$20) per ha per year would make transplanting more attractive than barley cultivation for 30% of the rangelands while PES of 7000 SYP (US$140) and 13,000 SYP or (US$260) per ha per year would increase the adoption rates to 60% and almost a 100%. The corresponding figures for direct seeding (right extreme curve in Fig. 2) would be 60%, 85% and a 100% respectively showing that resting has higher potential for adoption than transplantation at any level of PES. These results show that increasing the levels of incentive payments for the different management practices lead to higher adoption rates and that economic disincentives are barriers to adoption.

A major barrier to adoption relates to socio-cultural considerations and lack of adequate extension and institutional support. The socio-cultural considerations include the fact that barley cultivation is used both as a means to overcome short term forage problems and a means to control or appropriate the common pasture. Because the land tenure status of the *Badia* is common "open access" rangeland, entitled local users cannot prevent other non-entitled users from grazing the land, unless they cultivate it with barley. This means that due to lack of functioning rangeland governance, the legal status of rangelands presents a tenurial impediment to SRMPs. Furthermore, there is a perception amongst the *Bedouins* that the nutritional value and digestibility of fodder shrubs is low compared to barley. As a consequence they have less desire to adopt SRMPs as a substitute for barley cultivation.

5.1.2. Sensitivity analysis

Depending on the precision of measurement, scale and functional forms, certain parameters could be driving model results into one direction or the other. As a result, an *ex-ante* analysis of the potential for adoption of the SRMPs requires simulation of the model using different values of important variables such as prices, rangeland rehabilitation costs, and the discount rate (Fig. 3). Fig. 3 starts with the premises that: 1) rangeland rehabilitation by shrub transplantation is more costly than the other methods in general and the current practices of barley cultivation and open grazing in particular; and 2) cost-reducing measures are conceivable and likely to enhance its adoption. In this Figure, the first curve (left extreme) represents possible adoption levels of the new sustainable rangeland management practices (SRMP) if cost of adoption of the SRMP is equivalent to that incurred by the project (which is also used in this analysis to produce the results presented above). Without any incentive payments (current scenario), the adoption level for the SRMP is 10%. The question then presents itself as to how adoption of the SRMP would change if the cost of adoption was reduced? In answer to this we found a 10% cut in the establishment cost would see farmers adopt shrub transplantation on 55% of the lowland sites (Fig. 2: the curve representing the possible adoption levels shifts to right (second curve from the right)). In addition it is apparent that a 15% cut in the cost of adoption of the SRMP would result in an adoption rate of 65% (Fig. 2: the second curve from left shows that), while a 20% cut would increase the adoption rate to 73%. If the cost reductions were to be coupled with PES, the curves demonstrate that adoption levels increase substantially where a complete removal of the cost of adoption (i.e., 100% subsidy on the cost of adoption of SRMP) would lead to 100% adoption of all the SRMP.

5.2. Discussion

Through minimum data ex-ante modeling and in-depth focus group discussions with *Bedouins*, this study revealed that: 1) despite their traditional knowledge of advantageous principles of sustainable rangeland management, *Bedouins* did not change their

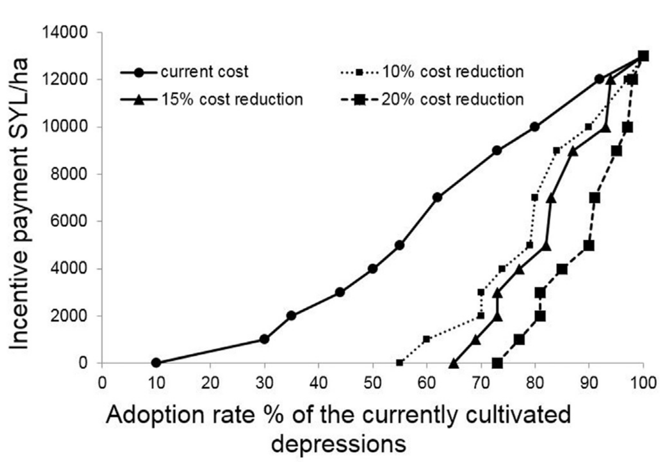

Fig. 2. Effect of cost reduction for transplantation.

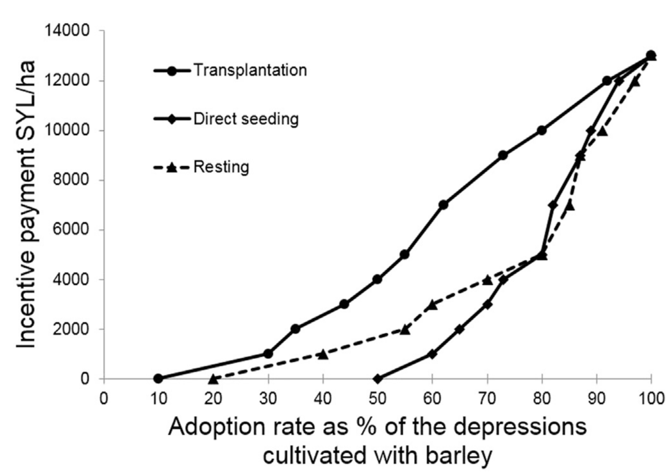

Fig. 3. Response of expected adoption rates to different levels of incentives.

unsustainable practices without receiving payments; 2) rangeland degradation in drought years had a severe impact on *Bedouins*' livelihoods and led to migration and conflict; 3) modest incentive payments would make SRMP more attractive than barley cultivation and, thus, contribute to restoration of degraded rangelands. Furthermore, the findings of this paper provide novel insights into how an *ex-ante* analysis of the impacts of financial incentives on rangeland management can be modeled in circumstances where only scarce information is available.

The first finding revealed a discrepancy between *Bedouin's* traditional norms of sustainable natural resource management and their actual behavior. This corresponds to empirical findings on sustainable management in other areas. Olbrich et al. (2014) for example, found no evidence of a significant change in actual land management behavior in a sample of commercial Namibian dryland cattle farmers despite their knowledge of SRMPs. Similar to the findings from the Namibian study, we hypothesize that the discrepancy between the existing norms and the actual behavior is because *Bedouins* pursue short-term profit in response to a perception that the Government is responsible for the management of the *Badia* and not themselves.

In terms of the social and economic consequences of poor long-term government policy, agricultural practice and rangeland management, it is of interest that Brzoska and Fröhlich (2015) and Koubi et al. (2012) found that severe rangeland degradation is a trigger for conflict at the local level. Such conflicts, they found, are both local and systemic – part of a system of conflict that has regional and, ultimately, national expression (see also Bromwich, 2009). Analyses of the relationship between unsustainable rangeland management, rangeland degradation, and conflict (in regional dryland contexts) show that while the causes of rangeland degradation in many developing countries are complex, degradation can be both a cause and a result of such conflict and is preventable with sound land management practices (Suliman, 2011; Bedunah and Angerer, 2012; Jacobs and Schloeder, 2012). Having said this, however, Brzoska and Fröhlich (2015) and Koubi et al. (2012) also argue that their findings do not describe a correlation between rangeland degradation and the violent conflict in Syria. This link is qualified by other determinants such as climate change and migration, and are, in any case, so complex that they defy a simple causal relationship. Thus while their findings describe an important pattern, any correlations and consequential considerations require more research. That said, it is our view that the study reported here reveals that severe rangeland degradation (and any risks of attendant socio-economic hardship and conflict) could be significantly alleviated with appropriate rangeland restoration and governance. The finding is noteworthy in the pre-war Syrian context where very little attention was given to SRMP by governments and international donor agencies (Dougill et al., 2012; Veldman et al., 2015).

Combating rangeland degradation necessitates the embodiment of biophysical solutions that are embedded on the ground along within an enabling socio-economic environment (Baartman et al., 2007). One important factor of such an enabling environment is financial incentives to solicit or enhance the support of local stakeholders. Such incentives have become increasingly important in the MENA region (Baartman et al., 2007). Model results clearly show that financial incentives are the key to the adoption of the three proven SRMP, each of which lead to improved land management and related productivity and, implicitly, reduced local conflict over scarce resources. The results of the *ex-ante* evaluation of adoption rate for SRMPs of lowlands demonstrate that despite the high potential yield of barley cultivation in these fertile lowlands, rehabilitated rangelands are more profitable for rangeland-based livestock production. Even without considering the environmental benefits and sustainability of improved rangeland, the mere introduction of the improved technologies may lead to adoption rates of 10, 50, and 20% for shrub transplantation, direct seeding, and periodic resting, respectively, when compared with barley cultivation.

The study confirmed the theoretical expectation that higher financial incentives lead to higher adoption rate of technologies for sustainable natural resources management. However, the conditions and concomitant requirements of rangelands are specific compared to other agricultural lands, because of the necessity of both security and flexibility for access, also described in the literature as the "paradox of pastoral land tenure" (Fernández-Giménez, 2002; Fernández-Giménez and Le Febre, 2006). While financial payments will provide good incentives for enhancing adoption of SRMPs, we believe that they need to be accompanied with institutional arrangements that enhance good governance. By drawing lessons from existing PES of forest areas, Dougill et al. (2012) find that for the success of PES schemes on rangelands, strong existing local institutions, clear land tenure, community control over land management and flexible payment schemes are vital.

The results of this study can be a first step towards a regional policy change away from barley subsidies as a strategy for supporting dryland rangeland users. The fact that governments could cost-effectively transform funds used for forage subsidies into agricultural-environmental payments should be a strong motivation for the governments to invest directly and much more sustainably in changing range management practices.

Some countries in the region have already started looking along those lines. For instance, discussions about sustainable investment in rangelands started in Jordan in 2014 regarding the use of incentive payments, strategies for increasing biodiversity and soil carbon sequestration as well as land degradation neutrality (Myint and Westerberg, 2015). It is also apparent that effective SRMP is a strong pillar for social stability. Following the civil unrest in Algeria, for example, most rural population living in remote areas have migrated to cities and urban areas. It was then found that as villages were deserted and village society was disrupted, terrorism spread. Thus, there is a need to have people occupy land and have access to services that assist them to do so. For this reason, the government of Algeria has put in place a strategy that aimed at reviving village economical and social life – and the return to stable social and political conditions (personnel communication).

The combined experience matched with the results of this study therefore provide valuable information for policy makers, donors as well as development and extension practitioners in the MENA region to the effect that further investment in reasearch towards generating low cost technologies and tailored governance strategies including a financial incentive system would lead to better management of rangelands and improvement of livelihoods.

6. Conclusions

In many countries in the MENA region, rangelands in the dryland areas are either communally or state owned. The main land use practices in the *Badia* are continuous grazing and cultivation of barley, which over the long run, degrade land and contribute to irreversible loss in biodiversity. A number of proven technologies – such as fodder shrub transplantation, direct seeding and periodic resting – are available and can reverse the degradation process while providing protein-rich livestock forage. However, these new management techniques have some short-term costs that necessitate compensatory and incentive arrangements if *Bedouins* are to find SRMP attractive.

Using a Syrian case study and the Minimum Data Analysis (TOA-MD) model, this study provided empirical evidence that the SRMP of shrub transplantation, direct seeding and periodic resting have only limited potential in increasing farm income and, hence, low potential adoption rates of 10%, 20% and 50%, respectively. However, accompanying their introduction with incentive payments in the form of payment for agri-environmental services of US$240/ha per year can increase the adoption rates of all the new managment practices to 100%. Though these levels of payments may appear too high, they can be justified on grounds that they enable to increase feed and forage supply in the *Badia* thereby contribute in the improvement of livelihoods. Moreover, they have very high social and environmental benefits as they increase the sustainability of the rangeland ecosystems, reduce desertification, enhancement carbon sequestration and so combat global warming.

Future research should focus on how adoption of SRMPs would affect the forage calendar in the *Badia*, and hence, the income of the *Bedouin* households with a view to the development of best practice for the implementation of agri-environmental and/or PES schemes on dryland rangelands combined with a conflict-sensitive and holistic rangeland governance.

The current non-adoption of SRMPs by the communities signals that there are economic, social, and cultural barriers at the local level. Moreover, the lack of technical and institutional capacity among decision makers and authorities inhibits the implementation of effective SRMPs. This study demonstrates a link between rangeland degradation, failed rangeland policies, and poor rangeland governance and so identifies an urgent need for governments in the MENA region to review their barley and/or forage subsidies and to opt for agricultural-environmental and/or PES schemes compatible with SRMPs.

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