FUNCTIONAL SILOS AND OTHER GOVERNANCE CHALLENGES OF RANGELAND MANAGEMENT IN ICELAND

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26 Keywords
27 Natural resource management, governance systems analysis, restoration, policy,
28 commons
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31 **Highlights**
32 □ Free roaming sheep during summer is forms the traditional rangeland grazing system in
33 Iceland.
34 □ Many of the grazed rangelands are in a degraded, even eroded, ecological condition
35 □ The Public authorities public employees within the rangelands´ SES have different
36 perceptions on what constitutes as SLM.
37 □ The vertical and horizontal dimensions of the rangelands´ SES are not fully
38 functionalintegrated.
39 The Rangelands, as a SES of, are not surrounding the rangelands´ utilization is not
40 managed through with adaptive governance (AG).processes
2
1 AG and co-adaptive management is needed to achieve sustainable rangeland utilization.
2
Abstract
7lEvery Social-ecological system (SES) promoting sustainable management of natural
8 resources in common ownership area is controlled steered in a complex governance system
9 that includes regulations through laws and policies, and, management d by the
10 administrative authorities operating across structure of the related multi-level institutional
11 structures that, in turn, are governance system and shaped driven by stakeholder interests.
In

12 addition,tThe long-term progress of natural resource management NRM not only thus relies
13 on upon the existence of a well-structured and functional governance system, but needs that
14 system to that adaptably facilitates sustainable resource management, in line with current
15 knowledge and best practices and in current knowledge.

16 In this research we mapped the administrative structure that of the governance system that steers
17 the of the SES of rangeland management in Iceland and undertook a critical
18 analysis of the subjected the governance system´s process to a critical analysis of its structure
19 and, functions to and governance approaches to estimate examine if the respective agricultural
20 and environmental policy targets had have facilitated system changes towards
21 improved sustainable rangeland management practices. A survey, based on a questionnaire
22 distributed to selected public sector employees and sheep farmers, was used to gauge the
23 participants: a) attitude towards rangeland management practices, b) perception of the level of
24 collaboration and state support for rangeland restoration and c) views on current agricultural and
25 environmental policies on rangeland management.
26 The results strongly indicate that neither the current administrative structure nor the governance
27 process itself have significantly facilitated the expected attitude changes within the agricultural
28 sector or among local authorities. Furthermore, it has neither facilitated significant attitude nor
29 behavioral changes among sheep farmers aimed at towards sustainable improved rangeland
30 management, in line with current government agricultural and environmental policy targets. Our
31 key findings support previous research that shows the governance system for rangeland
32 management in Iceland to structurally limited and suffering from weak vertically and
33 horizontally integration partially integration dysfunctional. Furthermore, our
34 findings clearly reveal the need for improved governance for rangeland management and the
35 requirement need for increased levels of knowledge application within the system.
36
37 **Introduction**
38 Sustainable land management (SLM) was defined by the UN 1992 Rio Earth Summit as: *"The*
39 *use of land resources, including soils, water, animals and plants, for the production of goods to*
40 *meet changing human needs, while simultaneously ensuring the long-term productive potential*
41 *of these resources and the maintenance of their environmental functions"*. In this paper, we use

it to define sustainable rangeland management. Well-functioning rangelands provide multiple ecosystem services, such as water purification and storage, and biomass production (see Havstad et al., 2007). They also and have an important role in climate change mitigation due to their capacity to sequester and store carbon in their biomass and soils (Lal, 2004; Cook et al., 2013).

These ecosystems provide economic and social benefits for local communities that rely on utilizing rangeland resources for human livelihood (Lund, 2007). However, substantive parts of the world´s rangeland systems are degraded and often ecologically dysfunctional due to unsustainable land use and poor resource management approaches (Marques et al., 2016).

Drawing upon Ostrom (2009), rangelands in communal or joint ownership are among one of among the many combined human-nature systems that are viewed as social-ecological systems (SES). The SESs outcomes are the result of the interrelationship between the resource systems, the actors that utilize the resources through certain resource units, and the related governance system that controls and manages that utilization.

UtilizationAn SES surrounding the utilization of rangelands in communal or collective ownership, when viewed as an SES, is an interconnected complex, one where the current social-ecological condition or changes within one of the SESs subsystems may affect changes within one of the SES subsystem or the system as a whole, by leveraging positive development or halting back further progress (McGinnis & Ostrom, 2014). Furthermore, the socio-economic functions within the Furthermore, the outcome is SES of rangeland utilization are driven by complex environmental governance processes (see Berkes, 2006 & 2008). The level of effectiveness and sustainability that a SES can achieve depends on how successfully these processes are governed vertically and horizontally (Okpara et al. 2018; Torfing et al., 2012), avoiding the creation of institutional fragmentation and functional silos that might otherwise might reduce optimal organizational functionality of within the SES (Zelli, 2015; Serrat, 2017).

The governance processes need, for instance, to be adaptive to enable them to continuously facilitate best practices within the SES (Schultz et al., 2015), multilayered and cross-scaled to facilitate allow for experimentation and learning (Dietz et al., 2003; Folke et al., 2005; Carlson & Sandström, 2008), and collaborative to address and build social cohesion and resolve potential conflicts among all the stakeholders involved (Karpouzoglou et al., 2016; Paavola, 2007).

Furthermore, aA well-functioning rangeland governance process within a defined SES, aiming

for sustainable resource utilization, needs to provide knowledge for iterative cycles of learning based on reflexive examination of the outcomes of earlier decisions (Dale et al., 2013) and continuously link new knowledge continuously to a comprehensive decision-making process. That way, the risk of knowledge gaps between sectors or stakeholder groups involved in the respective rangeland SES is minimized (Bouwen & Taillieu, 2004; Cundill & Fabricius, 2009). If rangeland exploitation is not governed through consensus towards a long-term sustainability of the SES in place, contrasting interests of various stakeholder groups may collide and even drive ressource over exploitation (Sayre et al., 2013; Brunson, 2012; Karl et al., 2012). Various governance approaches for natural resource management, such as rangeland management, are described in the literature (Lemos & Agrawal, 2006; Scarlett & McKinney 2016). An emerging one approach is adaptive governance, that based on references (Berkes & Folke, 1998; Gunderson et al., 2015; Folke et al., 2005; Olsson et al., 2006), is and defined by Hurlbert (2018) as a *"…range of political, social, economic, and administrative systems that develop, manage and distribute a resource in a manner that promotes resilience through collaborative, flexible, and learning –based issue management across different scales" (p 25)*.

Adaptive governance is recognized as an approach that includes all the key characteristics needed for building a well-functioning rangeland governance process (Karpouzoglou et al., 2016). In addition, a well-functioning rangeland governance process within a SES, This includes the needs to provide knowledge for collaborative and iterative cycles of learning based on reflexive examination of the outcomes of earlier decisions (Dale et al., 2013) and continuously linking new knowledge to a comprehensive decision-making process. In this way, Reflexive governance helps address the risk of knowledge gaps between sectors or stakeholder groups involved in the respective rangeland SES is minimized (Bouwen & Taillieu, 2004; Cundill & Fabricius, 2009). Furthermore, if rangeland exploitation is not governed through consensus, towards a long-term sustainability of the SES in place, contrasting interests of various stakeholder groups may collide and even drive resource overexploitation, particularity at a place-based scale (Sayre et al., 2013; Brunson, 2012; Karl et al., 2012).

The SESs of rangeland utilization worldwide are complex and various land use practices, other than livestock grazing, are often deeply interwoven in their utilization (Sayre et al., 2013). In Iceland the main methods of utilization of rangelands is is one of the countries in the world

16 where rangeland utilization, mainly for through free roaming sheep grazing, which has
17 traditionally been is of high socio-cultural and economic social-ecological importance. Thus,
18 although other types of utilization are growing in importance. Thus, the corresponding SES is
19 relatively simple compared to other countries where rangeland management hasis more often
20 embedded in multilayered SESs with has to address a variety of various utilization practices.
21 Rangeland Hence, The SES surrounding rangeland utilization in Iceland provides an
22 opportunity to therefore well-suited to research that explores the existing governance
23 arrangements and processes, including related policy targets, and estimate to an examination of
24 whether these if the structure and functions of its SES are supporting a robust SES in rangelands.
25 the implementation of the current rangeland policy targets.
26 From around 1990 onwards, the Icelandic government has sought to enhanced the sustainable
27 grazing management of the rangelands, introducing approved several new laws and, followed by
28 regulations to help achieve, aimed at achieving achieved policy targets on improved ecological
29 conditions. Various and enhanced sustainable grazing management of the rangelands. Since
30 1990, Various rangeland management strategies, such as agri-environmental schemes and
31 programs, have been introduced in support of this policy approach (Crofts, 2011). However,
32 Neither the governance processes nor neither the governance processes nor the outcomes of
33 these interventions have been examined in an integrative systematic manner. The
34 lack of a comprehensive evaluation provides a unique opportunity to explore the institutional
35 arrangements related to the SES of rangeland grazing management at a national level, and to
36 analyze further what type of the sustainability consequences of the governance approaches
37 and resource management approaches that are being applied within the system.
38 In this paper we: i) map the administrative structure of for the governance system of the SES of
39 rangeland management in Iceland; ii) subject the system to a critical analysis of its structure,
40 functions and governance approaches; and iii) estimate if the respective agricultural and
41 environmental policy targets have facilitated sustainable rangeland management practices,
42 within this SES estimate how well the governance structure is perceived to operate vertically and
43 horizontally
1 In particular, the paper explores: a) whether the actors in the governance system are encouraging
2 sheep farmers are being encouraged to apply sustainable rangeland management practices, in

3 line with existing policy targets, and by whom; b) the perception of the key administrative actors
4 within the governance system and of stakeholders (the sheep farmers) towards the current
5 management practices; and c) if the actors and stakeholders favour within the governance system
6 are favoring sustainable land management practices, as they are defined in Petursdottir, et al.
7 (2017) over and above other land management practices.
8
9 *Background*
10 Iceland is a parliamentary republic and a representative democracy. Although the country´s
11 population counts amounts to only approximately roughly 350,000 inhabitants, Icelandic
12 governance arrangements are structured in a relatively hierarchical administrative structure,
13 comparable to the administrative structure found within other European countries. Due to the
14 nation's small size, the governance arrangement for natural resources uses involve relatively few
15 public agencies within each administrative level, and it has smaller stakeholder groups than
16 found in, compared to more populated countries.
17 Iceland is around 103,,.000 km2, of which nearly 60% is categorized as highlands (>400 above
18 mean sea level). Approximately 40% of Iceland's the total land surface is state owned and over
19 85% of the highlands is categorized as commons (Óbyggðanefnd, 2019). Sheep farming for
20 lamb meat production is one of the main agricultural activities in Iceland. The lambs are born in
21 May and roam; roaming free with the ewe mothers on rangelands during summertime but
22 are gathered in late August or early September for fall slaughtering. Common grazing rights,
23 such as the right of most farmers to utilize local communal or collectively owned rangelands for
24 the free roaming sheep grazing during summertime, and traditions concerning collective sheep
25 gathering in the autumn thus form the social socio-economic backbone of the current sheep
26 farming system (Petursdottir et al., 2013; Ross et al., 2015). Although rangeland grazing is of
27 high socio-cultural, economic importance for sheep farmers (Stefánsson, 2018), research
28 shows that over 50% of the rangelands´ ecosystems are severely degraded and may be
29 considered as ecologically dysfunctional units, not suitable for their current grazing regime
30 (Arnalds, 2015; Arnalds & Barkarson, 2003; Arnalds et al., 2001).
31 Apart from the domestic sheep grazing, close to1000 domestic horses are grazed on several
32 commons in Northern Iceland during summertime (Halldórsdóttir, 2015). Other herbivores

utilizing the rangeland commons include migrating birds, such as geese and whooper swans, and around 5000 wild reindeer in reindeers in at the Eastern part of the country (Náttúrustofa Austurlands, 2019).

Rules concerning grazing management of communal areas in Iceland were already documented in Grágás, a book of law from the Commonwealth period (930-1262 AD) (Karlsson et al., 1992).

Nevertheless, unsustainable land uses, such as domestic livestock grazing and clear cutting of woodlands in earlier centuries, combined with harsh climate and fragile volcanic soil, led to severe soil and vegetation erosion and in many cases to ecosystem collapse (Arnalds et al., 2001). Soil conservation became an official governmental policy goal in the beginning of the 20th century, when recognition of rangeland degradation led to the first Icelandic *Act on forestation, soil reclamation and defences against desertification* (1907); and the first organized actions to combat land degradation was launched in the same year (Crofts, 2011). This was later followed up by the establishment of the Soil Conservation Service of Iceland (SCSI) (Crofts, 2011; Aradottir Petursdottir et al., 2013). The Act was revised in 1914, 1941 and 1965. (Aradóttir et al., 2013).

The Act was the first Icelandic Act stating the importance of preventing soil erosion and promoting improved land use (Aradóttir et al., 2013). The Act was revised in 1914, 1941 and in 1965 (Aradóttir et al., 2013). Sustainable rangeland management and ecosystem restoration, in addition to soil erosion, gradually started to gain further policy attention in the early 1960s, (Aradóttir et al., 2013) but only attained a legal status in December 2018 when the Icelandic parliament finally approved a new environmental *Act on Land Reclamation* (155/2018). This followed after several attempts over more than two decades to push for its revision over more than two decades (Crofts, 2011).

Although the concept of sustainable rangeland use started to gain attention in the early 1960s, it was not listed officially listed as a task in an agricultural policy until after 1990 (Table 1) and was first defined within an agricultural regulation in 2003. The concept has not yet been defined within any environmental legislation but according to the new *Act on Land Reclamation* (155/2018), the Mminister of Environment and Natural Resources has the authority to follow the Act up and set a new regulation with a new definition of offor what can be considered as sustainable (range)land use/management in Iceland.

but since then, the Icelandic government has approved several agricultural laws and regulations to direct rangeland governance toward sustainable rangeland management. Parallel, the

22 government supported various programs and projects aimed at increasing local and national
23 awareness on the multiple values of soil conservation and land reclamation, as well as to
24 facilitate sustainable management of rangelands (e.g. Arnalds, 2005; Crofts, 2011; Aradottir et
25 al., 2013; Petursdottir et al., 2013). These practices have focused particularly on building up
26 cross-sectorial agri-environmental actions intended to strengthen the cooperation between all
27 stakeholders involved in rangeland utilization, to improve rangeland management, and to restore
28 degraded rangelands (Crofts, 2011).The main land improvement programs and projects
29 established or facilitated in the last decades were, in chronological order: i) Farmers Heal the
30 Land program, ii) Local reclamation NGOs, iii) Quality Management in Sheep Farming and iv)
31 Land Improvement Fund.
32 i) Farmers Heal the Land program (FHL):
33 The FHL program was established by the SCSI in 1990 with the aim of increasing stakeholders´
34 involvement in rangeland management. The initial objectives of the FHL program were to
35 encourage restoration of degraded lowland rangelands and enhance trust and ease cooperation
36 between sheep farmers and relevant authorities, and also to facilitate behavioral changes towards
37 sustainable rangeland management (Arnalds, 1999; 2000). FHL is a governmental cost-shared
38 voluntary program that is operated nationwide by the SCSI, in close collaboration with its
39 participants (mostly sheep farmers). The program mainly supports restoration activities
40 performed on privately owned lowland rangelands (Petursdottir et al., 2017). Currently, roughly
41 550 farmers around the country participate in the FHL program (Einarsson, 2018).
42 ii) Local reclamation NGOs:
43 The *Act on Land Reclamation* approved in1965 permitted the establishment of local district
44 reclamation NGOs, although the first NGOs were not established until 1992. Since then,
14
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1 other local restoration NGOs have been established around Iceland, but according to the SCSI,
2 currently only 12 are active. The main aims of these NGOs are to: a) restore degraded communal
3 rangelands and b) strengthen environmental awareness and increase land literacy within the local
4 communities (Petursdottir et al., 2013). All the NGOs work on a voluntary basis, but work in
5 close cooperation with the SCSI. They receive grants from the SCSI and specific restoration
6 funds to buy fertilizer and seed for their projects (Crofts, 2011).
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Table 1. Icelandic agricultural laws, regulations and agreements that mention sustainable rangeland management.
10 Phrases or terms that refer to sustainable land use or grazing management are set in bold type (translations by Th.P.)

Year/no	***Title/description***	***Phrase or a term referring to sustainable land use or grazing management***
1993/99	Agricultural Product Act	If there is a risk that the activity goes against **preferable land use benchmarks.**
1995/124	Agricultural Product Act	Sheep farming/grazing must be in line with **environmental protection.**
1998/70	Farming Act	Land improvement should promote **sustainable land use** practices and take into account international commitments regarding conservation of biodiversity.
2000/88	Agricultural Product Act	Quality Managed Sheep (QMS) production is verification for lamb meat, produced in accordance to with standards on defined production process, health and **environmental protection**. Sheep farming shall be in line with **environmental protection, land qualities and preferable land use benchmarks.**
2002/101	Agricultural Product Act	Land use must be sustainable so that the **production capacity of the land is adequate and land utilization limited to keeping the vegetation cover in equilibrium or improving**, in the opinion of the SCSI.
2003/173	Regulation for Quality Management in Sheep Farming (QMS)	Definition for sustainable land use: maintaining **adequate biomass productivity and land utilization within the limits of keeping the vegetation cover in equilibrium or? or in improvement**, in the opinion of the SCSI.
2007/58	Agricultural Product Act	Sheep farming is practiced in accordance to with **environmental protection, land qualities and sustainable land use practices**. Quality Managed sheep production is verification for lamb meat, produced in accordance to with certificated standards concerning animal welfare, **sustainable land use practices** and healthy products.
2007	Agreement between the State and farmers, of the working condition in sheep farming	Sheep farming is practiced in accordance to with **environmental protection, land qualities and sustainable land use practices**.
2013/1160	Regulation for Quality Management in Sheep Farming (QMS)	Definition for sustainable land use: **The use of land resources, including soils, water, animals and plants that do not deplete terrestrial natural resources**, **while simultaneously ensuring the long-term productive potential of the ecosystems and the maintenance of their functions.**
2016	Agreement between the State and farmers, of the working condition in sheep farming	

To promote the production of lamb meat certified by the QMS verification system, including all involved factors such as animal welfare, healthiness of products and **sustainable land use practices**.
2017/1166 Regulation for Quality
Management in Sheep
Farming (QMS)
Definition for sustainable land use: **The use of land resources, including soils, water, animals and plants that do not deplete terrestrial natural resources**, **while simultaneously ensuring the long-term productive potential of the ecosystems and the maintenance of their functions.**
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12 Since 1990, the Icelandic government has approved several agricultural laws and regulations,
13 aiming to direct aimed at rangeland governance toward sustainable rangeland management. In
14 Parallel, the government supported new programs and projects aimed at increasing local
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1 and national awareness on the multiple values of soil conservation and land reclamation, as well
2 as to facilitate the sustainable management of rangelands (e.g. Arnalds, 2005; Crofts, 2011;
3 Aradottir et al., 2013; Petursdottir et al., 2013).
4 The “Farmers Heal the Land” (FHL),, a governmental cost-shared voluntary program,
5 established by the Soil Conservation Service SCSI in 1990, was for instance the first
6 governmental program with a clear aim of increasing stakeholder (mostly sheep farmers´)
7 involvement in rangeland management. The initial objectives of the FHL program were to
8 encourage restoration of degraded lowland rangelands, to enhance trust and ease cooperation
9 between sheep farmers and relevant authorities, and to facilitate behavioral changes towards
10 sustainable rangeland management (Arnalds, 1999; 2000). The program mainly supports
11 restoration activities performed on privately owned lowland rangelands (Petursdottir et al.,
12 2017). Currently, roughly 550 farmers around the country participate in the FHL program
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31 currently only 12 are active. The main aims of these NGOs are to: a) restore degraded communal
32 rangelands and b) strengthen environmental awareness and increase land literacy within the local
33 communities (Petursdottir et al., 2013). All the NGOs work on a voluntary basis, but work in
34 close cooperation with the SCSI. They receive grants from the SCSI and specific restoration
35 funds to buy fertilizer and seed for their projects (Crofts, 2011).
36 Late in the 1990s, the Icelandic government took another elarge step towards acknowledging the
37 need for improved rangeland management by adding the issue as a compulsory pillar to the
38 Quality Management in Sheep Farming (QMS).) Sscheme. iii) Quality Management in Sheep
39 Farming (QMS):
40 The QMS is a cross-compliance scheme that was formally introduced by the Ministry for
41 Industry and Innovation in the Agricultural Commodities Agreement in 2000 and came into
42 force in 2003 with the approval of the Legislation for Quality Management in Sheep Farming
43 (QMS) (Table 1) (Arnalds & Barkarson, 2003). One of the aims of the QMS's aims is to secure
9
1 sustainable rangeland grazing management. Participation in the scheme is voluntary but sheep
2 farmers that apply and successfully fulfill the QMS requirements of good farming practices
3 and sustainable land use receive close to 30% higher subsidy payments from the State for their
4 production than non-participating farmers (Karlsson et al., 2015; Þorláksdóttir, 2015). Currently,
5 approximately 1,750 sheep farmers (Ásbjörnsson, 2015), producing more than 90% of the
6 annual lamb meat production (Karlsson et al., 2015), participate in the QMS.
7 The Icelandic Food and Veterinary Authority control the QMS approval process, but the SCSI is
8 responsible for: a) estimating the ecological condition of the rangelands utilized by QMS
9 applicants/participants and b) verifying if the grazing areas under inspection fulfill the criteria
10 for sustainable land use, as defined in the scheme´s regulation. If the observed grazing areas do

not fulfill the minimum ecological requirements, the respective applicants/participants must provide and follow a ten-year restoration plan with measureable targets to qualify for subsequent participation in the scheme. Once such restoration plans are validated by the QMS system, the grazing of the respective areas is deemed sustainable and the farmers relying on grazing them for their meat production receive full QMS subsidy payments (Regulation for Quality Management in Sheep Farming, (QMS), 2013/1160). According to Arnalds et al. (2000) there are 72 rangeland commons or collectively owned rangelands in Iceland but it is not clear how many of these areas are utilized for sheep grazing within the QMS. Nevertheless, 26 rangeland commons or collectively owned rangelands do not meet the minimum ecological condition requirements of the QMS and need to work in accordance to a ten-year restoration plan (Ásbjörnsson, 2015).

In 2003, the government established the Land Improvement Fund (LIF) as a follow-up project to the QMS scheme, mainly to support farmers who, according to the scheme, need to restore some of their grazing areas to receive the annual QMS subsidy payments iv) Land Improvement Fund (LIF):

The LIF was established in 2003, mainly as a follow-up project to support farmers who, according to the QMS scheme, need to implement restoration to receive the annual QMS subsidy payments. The fund is financed by the state central government and managed by the SCSI, but the Sheep Farmers Associations also give an annual financial contribution to the Fund. The main goals of the LIF are to: a) halt soil and vegetation erosion and prevent further land degradation, b) restore degraded ecosystems, in accordance with potential vegetation conditions and land use requirements, c) facilitate sustainable land use and d) mitigate climate change impacts through increased carbon sequestration in soil and vegetation (Eiríksson et al., 2018). Supported projects entitled to support must meet these goals and applicants that submit a comprehensive restoration/land use plan have priority for funding.

Since its establishment, the LIF has emphasized focused on supporting compulsory QMS restoration projects, which now comprise over 50% of all allocated grants in 2017 (Eiríksson et al., 2018).

Data collection and analysis

To understand better the rangeland governance system, we mapped the system´s formal administrative structure with through the use of secondary data sources and

43 information from respective appropriate webpages. We then used the results from a pilot study
10
1 investigating rangeland management in Iceland from a social-ecological system´s perspective
2 (Petursdottir et al., 2013) to structure questions for an online survey. The online survey was
3 administrated in the winter 2011-2012, and circulated to public employees identified as having an
4 administrative role in rangeland management (Table 2). In total, of 503 people received a link to
5 the questionnaire, each receiving. Each of them received an email with a personal e-link and
6 password. to the questionnaire. Two weeks later, a short reminder was circulated by email to those
7 that had not yet replied, and again after a lapse of three weeks and of four weeks. Participants from
8 the Agricultural University had shorter time to reply and only received two reminders, as its
9 postmaster inadvertently blocked the survey email for two weeks until this error was discovered.
10 **Table 2.** Hierarchical and structural locations of people within the agri-environmental governance system, identified
11 by the authors of this paper to have a role in rangeland management. Those that regularly are in “face to face”
12 contact with farmers in their work are considered to have direct interactions with them, those that irregularly or even
13 never meet with the farmers are considered to have indirect interactions with them.

Position	***Role***	***Interactions with farmers***
Institute/ institution/ organization		
Parliamentarians	Elected members of the Icelandic parliament. National policies and laws	N/A
National Assembly		
Ministry experts	Administration and communication to all related stakeholder groups and institutes. Preparing laws and regulations for approval and implementation	Indirect
Ministry for Environment and Natural Resources and Ministry for Industry and Innovation (incl. agriculture)		
Aldermen (regionals)	Elected member of regional authorities. Local administration and decision making, regional policy design and implementation	Indirect
Regions, defined by the state to highly depend on sheep farming		
University lecturers/professors	Research and consultancy in her/his field of expertise and providing education in agricultural and/or environmental science	

to students
Indirect/direct Agricultural University
Agricultural advisors Advising farmers on livestock breeding,
livestock husbandry, agronomy and
farm accounting
Direct Farmers Association
Icelandic Agricultural
Advisory Centre
Agricultural experts/managers Administration and interest monitoring for
the agricultural sector
Indirect/direct Farmers' Association
Icelandic Agricultural
Advisory Centre
Environmental advisors Advising farmers on rangeland grazing
and ecosystem restoration, supervisory
of land condition
Direct Soil Conservation Service
Environmental experts/managers Administration, monitoring of land
condition, control of land management,
diverse research focusing on terrestrial
ecosystems
Indirect Soil Conservation Service,
Forest Service, Institute of
Natural History, National
parks
Afforestation advisors/park rangers Advising farmers/land owners on forestry,
planning and monitoring afforestation
projects/ controlling of protected areas
Direct/indirect Forest Service, National
parks
14 We also sent the survey to sheep farmers to enable comparison of answers with those from the
15 various positions listed in Table 2. In parallel to the online survey, a hard
16 copy with a pre-paid return envelope was posted to 1261 sheep farmsteads. According to the
17 Icelandic Agricultural Statistic (2010) this represented 87% of all registered sheep farms in
18 Iceland at that the time. The sampling method is described in further detail by Petursdottir et al.

1 (2017). Both parts of the survey were posed with permission from the Icelandic data protection
2 authorities.
3 The survey questions were divided in three categories: Category 1 measured the attitude of
4 participants in the survey towards rangeland management; Category 2 measured their perception
5 on of the level of collaboration and state support for rangeland restoration; and Category 3
6 asked about their views on current agricultural and environmental policies on rangeland
7 management and on whom should be involved in designing and implementing policy targets

8 concerning rangeland management and restoration.
9 Each category consisted of two to four main questions, followed by two to six sub-questions; 30
10 questions in total. The participants were asked to express how much they agreed or disagreed
11 with given statements, using a five-step Likert scale (Neuman, 2006).
12 A Wilcoxon-Mann-Whitney, non-parametric test (Townend, 2009), was used to compare all
13 replies divided by sectors. Furthermore, in the cases where the Mann-Whitney test showed a
14 significant difference in response between the environmental and the agricultural sectors, the test
15 was run again based on the profession of the participants (Table 2). A Friedman test was used to
16 assess whether the ranking of the replies across all sectors were identical. The test was
17 performed independently for the replies from each sector.
18 **Results**
19 *Mapping the governance system´s structure*
20 Legislation concerning rangeland management is prepared by the Ministry of Industries and
21 Innovation (MII), the Ministry for the Environment and Natural Resources (MENR) and related
22 governmental institutes, in collaboration with all main stakeholder groups (Fig.1). All new law
23 must be approved by the majority of the parliamentarians at Althing but the respective minister
24 prepares new legislations and is granted power to make more detailed provisions of approved law
25 by setting regulations. Currently, only the MENR runs an administrative office dealing with
26 sustainable land management, including restoration and reforestation, whereas the MII has neither
27 an official internal employee office nor a scientific or an administrative institute agency under its
28 auspice that addressing addresses rangeland management. Professional advice and small scale
29 financial support to sheep farmers concerning rangeland management and restoration (including
30 reforestation) are only provided by the extension service of the SCSI and the IFS (Icelandic Forest
31 Service), both institutes agencies under the auspice of the MENR (Table 2). Thus, the MENR
32 holds the scientific and the professional knowledge for designing and following-up environmental
33 policies and regulations related to rangeland management, while the MII holds the official
34 decision-making capacity and the authority to set agricultural policies and regulations concerning
35 rangeland management through the agricultural subsidy system, including the QMS payments.

36 The state government, the above mentioned ministries and related governmental institutes, such
37 as the Soil Conservation Service (SCSI), are key public institutions involved in policy setting and
38 follow-up processes concerning rangeland management. Other main organizations contributing to
39 the design and implementation of agri-environmental policies concerning rangeland management
40 are the Farmers' Association, local authorities and environmental NGOs (Fig. 1).
12
1
2 Figure 1. The political-administrative structure of the Icelandic governance system related to governing rangelands in
3 Iceland. management.
4 Organizations and institutions that play an active role in the process of designing and implementing agri-
5 environmental policies for rangeland management are denoted inbyin beige shapes; , but agencies that are less actively
6 involved in the process are denoted inbyin gray. (NPs1= National Parks; IINH2= Icelandic Institute of Natural History;
7 IFS3= Icelandic Forest Service; SCSI4= Soil Conservation Service of Iceland; AUI5= Agricultural University of
8 Iceland; FA6= Farmers Associations; IAAC7= Icelandic Agricultural Advisory Centre).
9 In line with the prevailing law and regulations, the organizations and institutions that play an active
10 role in the process of designing and implementing agri-environmental policies for rangeland
11 management are shown in beige in Figure 1 but the agencies that are less actively involved in the
12 process are gray (Fig. 1). The dashed line from the Ministry of Industry and Innovation to the
13 Farmers´ Association symbolizes an indirect administrative connection, as the FA is a private
14 business interest organization, only partially funded by the state. The dotted line from the
15 Agricultural University to the Soil Conservation Service, to the Farmers' Associations and to the
16 sheep farmers symbolizes the indirect lines of influence between these agencies as they fall under
17 or are linked to the political auspices of different ministers (Fig. 1).
18 There is no cross-sectoral team of policy experts focusing on all social-ecological aspects related
19 to rangeland management in place within the governance system. Furthermore, no formal agri-
20 environmental transdisciplinary platform for knowledge application and decision-making exists
21 (Fig. 1).
13
1 The SCSI plays a key administrative role in implementing rangeland management policies. B but
2 the Farmers Association (FA) also has a role in the implementation phase, both as a

3 business interest organization, advocating for the business interests of their sectoral member
4 organizations, and through the Icelandic Agricultural Advisory Centre (IAAC), a
5 private corporation owned by the FA (Fig. 1) that runs a nationwide network of agricultural
6 extension offices. The FA is run and financed by the farmers themselves but also receives annual
7 fixed payments from the State in accordance with agricultural agreements from 2015, with part of
8 that amount allocated to the advisory system of the IAAC.
9 The Agricultural University of Iceland (AUI) is responsible for the education of the majority of
10 acting sheep farmers and many of the employees of FA, IAAC and the SCSI. The AUI is only
11 loosely linked to the policy process concerning rangeland management as it falls under the
12 auspice of the MESC (Ministry of Education, Science and Culture) but is without any formal
13 land use policy-making connections to the MII (Fig. 1).
14 According to the *Act on Rangelands* no.6/1986, decisions on rangeland grazing management
15 practices are in the hands of local authorities. Thus, local authorities are also directly embedded
16 in the governance process as most of the rangelands are in public or mixed ownership, under
17 local custody or collectively owned by two or more landowners. Environmental NGOs and other
18 stakeholder groups, including the general public, participate indirectly in the governance process
19 by, for instance advocating for improved rangeland management and commenting on
20 governmental plans concerning land use.
21
22 *Survey*
23 In all, 234 of the 503 questionnaires distributed online were returned. Of these, 17 copies were not
24 properly filled out, resulting in a sample of 217. (Table 3). 480 of the 1261 questionnaires mailed
25 to sheep farmers were returned. Of these, 13 copies were not properly completed, giving a final
26 sample of 467.
27 The number of replies varied among numbers based sectors (Table 3). The answering
28 rate from parliamentarians, for example, was only 14%.% (Table 3). An additional 14% of
29 parliamentarians wrote a personal mail to the survey coordinator explaining that they tried to reply
30 to the questionnaire but felt they lacked the knowledge and expertise needed to answer.
The replies from the sheep farmers were distributed among all quarters of Iceland and varied
32 from 32% reply rate in the South to 48% in the East. There was no significant difference
($P<0.05$)
33 in the rate of response between genders or age groups and the average age bracket was 50-60
34 years.

35 **Table 3. Answering rate to the survey from different institutions and organizations, divided by sectors.**

Name / Sector	***Type***	***Level***	***Role***	***Sent surveys***	***Received replies***	***Reply rate (%)***
National assembly / **Officials**	Parliament	National	National policies/laws/ democracy/ cooperation	63	9	14
Ministry for environment and natural resources (MENR) / **Officials**	Governmental department	National	Administration/ legislations environmental policies/ international cooperation	21	6	29
Ministry for industries and innovation (MII) / **Officials**	Governmental department	National	Administration/ legislations agricultural policies/ international cooperation	17	4	24
Municipalities/ **Local authorities***	District government	Regional	Administration/ regional policies	131	57	44
The Agricultural University of Iceland (AUI) / **Education**	State university					

National
(MESC***)
Secondary and
tertiary
education/research/
policy inputs
65 18 28
The Farmers Association (FA)
Agricultural
Business
Interest
organization
National
Administration/policy
interest monitoring
50 64 65
The Icelandic Agricultural Advisory
Centre (IAAC). **Agricultural**
Sister company
of the FA
National Agricultural advisory 48 ↑ ↑
The Icelandic Institute of Natural
History (IINH). **Environment**
Governmental
institute
National
(MENR)
Monitoring/research/
policy inputs
20 76 70
National parks (NP)**
Environment
Governmental
agencies
National
(MENR)
Control/information/
policy inputs
17 ↑ ↑
The Icelandic Forest Service (IFS)
Environment
Governmental
institute
National
(MENR)
Practice/control/advis
ory/
research/policy
inputs
45

↑ ↑
The Soil Conservation Service of
Iceland (SCSI). **Environment**
Governmental
institute
National
(MENR)
Practice/control/
advisory/
research/policy
inputs
26
↑ ↑
1 Overall 503 234 47
2 ↑Symbolizes that all the replies from respondents within the agricultural sector were merged to one number; so were all the replies
3 from respondents within the environmental sector
4 *Local authorities of all regions officially defined as economically depending on sheep farming
5 **All permanent staff of the Vatnajokull, Thingvellir and Snaefellsnes national parks
6 ***Acronym for the Ministry of Education, Science and Culture
78
Rangeland management
9 All sectors (Table 3) strongly supported the position that sheep grazing should be practiced on
10 highland commons that according to scientific research results have sufficient carrying capacity
11 (Table 4). Nevertheless, significantly fewer ($P<0.05$) respondents from the sectors of
12 agriculture, local authorities and sheep farmers, compared to than those from the education and
13 environment sectors, felt that decisions on what land is suitable for grazing should depend on
14 expert advice or supported the statement that highland commons should preferably not be grazed
15 (Table 4).
16 The educational and environmental sectors were significantly more ($P<0.05$) in favor of limiting
17 the grazing period in the highland commons from mid-June to end of August and were also more
Commented [31]: I don't think there is need to cite the table more than once in the paragraph, unless you are citing multiple tables and there is a question which one applies.
15
1 supportive ($P<0,05$) of the practice of sheep grazing on collective lowland areas, compared to
2 the agricultural sector, local authorities and the sheep farmers (Table 4). Furthermore, the
3 educational and environmental sectors and the officials were significantly less ($P<0.05$)
4 supportive of the current rangeland grazing management system, and of grazing rangelands until
5 it starts to snow in the autumn, or of grazing rangelands in winter, than were the

6 regional authorities? s and the sheep farmers.
78
Table 4. Mean rankings (1= strongly disagree – 5= strongly agree) of all agents (by sectors of profession; Table 2)
9 and the sheep farmers´ attitude concerning how to manage sheep grazing on highland commons and other
10 rangelands. Education = agents working at the AUI (N = 18), Environment = agents working at the IINH, NPs, IFS
11 and SCSI (N = 76), Officials = parliamentarians and agents working at the MENR and MII (N = 19), Agriculture =
12 agents working at the FA and FAS (N = 64), Regionals = members of the local authorities within regions officially
13 defined to be depending on sheep farming (N = 57) and sheep farmers (N = 467). Mean ranks within rows identified
14 with the same superscript letter were not significantly different ($P > 0.05$).

Attitude towards rangeland management	**Education**	**Environment**	**Officials**	**Agriculture**	**Regionals**	**Sheep farmers**
1) Lenght of the grazing period at the highland commons:						
a) Never before mid of June	3.9 a	3.8 a	3.4 ab	3.0 b	2.7 c	2.5 c
b) Never longer than till end of August	3.2 a	3.1 a	2.4 b	2.1 b	2.2 bc	1.9 c
2) Sheep grazing shall be practiced on:						
a) currently grazed areas	2.2 a	2.4 a	2.7 ab	3.1 b	3.8 c	3.9 c
b) highland commons that, according to research have sufficient carrying capacity	4.1 a	4.1 a	4.2 a	4.2 a	4.3 b	4.1 a
c) collective fenced areas in the lowland	3.7 a	3.7 a	3.8 a	3.0 b	2.7 b	2.7 b
d) fenced, privately owned lowland	4.0 a	3.9 a	3.8 a	3.5 a	3.1 b	2.9 b
e) in areas depending on sheep farming	2.7 a	2.8 a	2.9 ab	2.7 a	3.3 b	3.2 b
3) It's acceptable to graze rangeland in the lowland:						
a) until it starts to snow in the autumn	2.4 a	2.7 ab	3.2 b	3.2 b	3.5 c	3.3 bc
b) never in winter	3.8 b	3.9 b	3.6 ab	3.3 a	3.0 a	3.2 a
4) Land considered suitable for sheep grazing:						
a) grassland and well vegetated land	4.6 a	4.4 a	4.1 a	4.5 a	4.3 a	4.5 a
b) depends on experts' advices	4.1 a	4.0 a	4.0 a	3.5 b	3.4 bc	2.9 c
c) poorly vegetated land should not be grazed	3.9 ab	4.3 a	3.8 b	3.8 b	3.8 b	3.6 b
d) highland commons should preferably not be grazed	2.9 ab	3.1 a	2.7 ab	2.2 b	2.3 b	2.0 b

15
16 *Collaboration*
17 Over 75% of all respondents agreed with the statement that farmers work cooperatively on
18 restoration projects, that they are not only forced by law and legislation to practice restoration
19 and that their work is implemented in good collaboration with the SCSI (Table 5). Over 60% of
20 all respondents see restoration as a societal responsibility that the state should
21 subsidize, although this was significantly less ($P<=0.05$) favored by the officials, compared to

22 the agricultural sector and the sheep farmers. The environmental and the educational sectors and
23 the officials were significantly more ($P<0.05$) in favor of keeping restoration subsidies low low,
24 than were the other three sectors. were (Table 5).
Commented [32]: Unclear meaning:
Is it: that they are NOT forced by law..
Or
That they are forced by law …
The phase 'not only' is confusing
16
1 **Table 5.** Mean rankings of all employees (by sectors of profession; Table 2) and the sheep farmers´ attitude
2 concerning collaboration and incentives in rangeland restoration (1= strongly disagree – 5= strongly agree).
3 Education = agents working at the AUI (N = 18), Environment = agents working at the IINH, NPs, IFS and SCSI (N
4 = 76), Officials = parliamentarians and officials working at the MENR and MII (N = 19), Agriculture = agents
5 working at the FA and FAS (N = 64), Local authorities = members of the local authorities within regions officially
6 defined to be depending on sheep farming (N = 57) and sheep farmers (N = 467). Mean ranks within rows identified
7 with the same superscript letter were not significantly different ($P > 0.05$).

Attitude towards collaboration	**Education**	**Environment**	**Officials**	**Agriculture**	**Local authorities**	**Sheep farmers**
1) Collaboration in rangeland restoration:						
a) Farmers work cooperatively in restoration projects	3.9 a	4.2 b	4.1 a	4.3 b	4.2 b	3.9 a
b) Law and legislations force farmers to practice restoration	2.7 b	2.3 ab	2.4 ab	2.3 ab	2.4 ab	2.2 a
c) Good cooperation between farmers and SCSI	3.7 a	4.2 c	4.3 c	4.0 b	4.1 bc	4.0 b
d) The agri-environmental sectors are jointly planning restoration projects	3.5 a	3.4 a	3.6 a	3.4 a	3.5 a	3.3 a
2) Direct incentives for increased restoration:						
a) Restoration is a societal task the state should subsidize	3.9 ab	4.1 ab	3.7 b	4.2 a	3.9 ab	4.1 ab
b) Restoration subsidies should be low	3.2 b	3.0 b	3.2 b	2.7 a	2.7 a	2.6 a

89
Governance and policies
10 All sectors, with the exception of the except the officials (the parliamentarians
11 and ministry officials) strongly supported the argument that rangeland restoration should be 12 managed at a regional level (Table 6). The environmental and the educational sectors and the 13 officials were significantly less in favor of the statement that rangeland restoration should be 14 under the control of the Farmers Association, compared to the other sectors (Table 6). All
15 sectors strongly supported the argument that the study of rangeland restoration should be part of

16 the compulsory curriculum for all those studying agricultural science, although sheep farmers
17 were significantly less ($P<0.05$) in favor of this view, compared to the environmental sector.
18 Close to 50% of all respondents supported the argument that state rangeland restoration policies
19 lack focus and clarity of purpose. Additionally, around 40% of the respondents neither agreed
20 nor disagreed with the statement (Table 6). Responses to the statements that the FA actively
21 participates in designing rangeland restoration policies and that rangeland restoration policies are
22 designed in collaboration with farmers/land users were ambivalent. All sectors strongly
23 supported the statements that municipalities should actively participate in designing restoration
24 policies, and that agricultural and environmental institutes should follow a joint policy for
25 restoration and sheep grazing, although in both cases the sheep farmers were significantly less
26 supportive than were the environmental sector. (Table 6).
27
28 **Table 6.** Mean rankings of all employees (by sectors of profession; Table 2) and the sheep farmers´ attitude towards
29 governance and policies concerning rangeland restoration and management (1= strongly disagree – 5= strongly
30 agree). Education = agents working at the AUI (N = 18), Environment = agents working at the IINH, NPs, IFS and
31 SCSI (N = 76), Officials = parliamentarians and officials within the MENR and MII (N = 19), Agriculture = agents
32 working at the FA and FAS (N = 64), Local authorities = members of the local authorities within regions officially
33 defined to be depending on sheep farming (N = 57) and sheep farmers (N = 467). Mean ranks within rows identified
34 with the same superscript letter were not significantly different ($P > 0.05$).
17

Attitude towards governance and policies	**Education**	**Environment**	**Officials**	**Agriculture**	**Local authorities**	**Sheep farmers**
1) Rangeland restoration:						
a) Should be managed at a regional level	4.1 ab	4.4 a	3.2 c	4.2 a	4.1 ab	3.9 b
b) Should be under the custody of the SCSI*	3.2 a	3.5 a	3.5 a	3.6 a	3.3 a	3.5 a
c) Should be under the custody of the FA*	2.6 a	2.7 a	2.5 a	3.1 b	3.3 b	3.3 b
d) Should be part of the compulsory curriculum for all studying agricultural science	4.3 a	4.5 a	4.1 ab	4.1 ab	3.9 bc	3.7 c
2) Rangeland restoration policies:						
a) Governmental policies are focused and clear	2.5 a	2.3 a	2.7 a	2.5 a	2.6 a	2.5 a
b) The FA actively participate in designing governmental rangeland restoration policies	3.1 ab	2.6 a	3.1 ab	2.8 a	3.2 b	3.1 ab
c) The government design rangeland restoration						

policies in collaboration with farmers/land users 3.3 a 3.1 a 3.8 b 3.3 a 3.3 a 3.2 a
d) The ministries for agriculture and environment
should jointly form governmental restoration
policies
4.2 bc 4.4 c 4.2 bc 3.9 b 3.9 b 3.6 a
e) Municipalities should actively participate in
designing governmental restoration policies 4.2 bc 4.3 c 4.2 bc 4.1 b 3.9 ab 3.8 a
f) Agricultural and environmental institutes should
follow a joint policy for restoration and sheep
grazing
4.1 bc 4.3 c 4.2 bc 3.8 b 4.0 b 3.5 a
12
18
1 **Discussion**
2 This research mapped the political-administrative structure of the governance system for
3 rangeland management in Iceland. It and assessed through a national survey if the
governance
4 process within the system was likely to enhance sustainable improved rangeland
management
5 practices among sheep farmers, in line with current agri-environmental policy. Based on the
6 results, we also estimated how well the governance structure is perceived to
7 operate vertically and horizontally. The findings introduced in this paper are based on
replies
8 from 38% of all Icelandic sheep farmers (480 replies) that were member of the Sheep
farming
9 association at the time the research was conducted and 47% of all public/partially public
10 employees (234 replies) identified to have as having a direct or indirect administrative role
11 within the governance system of rangeland management..
12 The survey revealed substantial difference in what the different sectors considered to be
good
13 rangeland management practices (Table 4). The public administrators, (officials), the
environmental and the educational sectors have, for instance,
15 recognized the importance of sustainable rangeland management strategies to a greater
extent
16 more than does the agricultural sector and local authorities. The latter two sectors, along
with the
17 sheep farmers, favored the traditional rangeland utilization practices as described earlier in
this
18 paper, while the replies from the environmental and the educational sectors were more in
line
19 with contemporary understandings for of what practices should be considered as
sustainable
20 rangeland management in Iceland, as described in Petursdottir et al. (2017).
21 These results are in line with several other recent Icelandic research findings indicating
that also
22 indicating that the QMS scheme and above mentioned interventions might not be
23 facilitating long-term system transition towards sustainable rangeland management as
intended.
24 Petursdottir et al. (2013; 2017), for instance, found that for instance that even though
sheep

25 farmers shared positive attitudes among sheep farmers toward restoration and were even their
26 actively participation in rangeland restoration projects, (governmental ones or on their
27 voluntary projects own), this did not influence their rangeland management practices in
28 practice. Furthermore, and that lack of cooperation between the agricultural and environmental
29 sectors might be preventing the desired policy development. Furthermore, Berglund et al. (2013)
30 stated that participatory practices were weak in rangeland restoration projects, with respect to the
31 role of stakeholders in policy development. Similarly, Þorláksdóttir (2015) found that farmers in
32 North East Iceland participating in the QMS for rangeland management felt that they are not
33 given an active voice within the system, claiming that the scheme is too “top down”, that there is
34 limited consensus between different actors in relation to priorities and methods, and that the
35 objectives of sustainable land use and restoration are unclear. Finally, according to the findings
36 of Stefánsson (2018) a selection of governmental employees working on within the governance
37 system of rangeland management find the QMS to be lacking functionality, eventually not
38 achieving the target of halting unsustainable rangeland utilization.
39 All these findings can be linked to the limitations on how the characteristics concept of
40 sustainable land management/land use has been defined and disseminated by the agricultural
41 sector within the governance system of the SES of rangeland management.
42 A thorough ecological understanding, derived from both scientific and traditional ecological
43 knowledge, is claimed to be a fundamental pillar for sustaining an effective adaptive governance
44 system of an SES (Folke, 2006; Bark et al., 2012). One of the initial aims of the QMS scheme
45 was to build up ecological understanding and facilitate behavioral changes among sheep farmers

1 towards more sustainable rangeland management by setting a legal framework to clarify what
2 can be considered as sustainable rangeland use (Arnalds, 2019). Nevertheless, since 2003, the
3 term sustainable land management (SLM) has officially been defined by the agricultural sector
4 and appeared in agricultural regulations as a short, well-defined scientific term (Table x)), rather
5 than instead of being regarded more as a framework, one that incorporates the various
6 dimensions of including the various aspects behind sustainability; such as productivity, security,
7 protection, viability and acceptability (FAO skilgreiningin). This narrow approach has been

8 highly criticized by environmental scientists and the SCSI, pointing out that the current SLM
9 definition leaves out fundamental ecological principles, such as the current ecosystem condition
10 and thus, is incapable of clarifying what can be considered unsustainable land management
11 (Arnalds, 2019).
12 Berglund et al. (2013) stated that participatory practices were weak in rangeland restoration
13 projects, with respect to the role of stakeholders in policy development. Similarly, Þorláksdóttir
14 (2015) found that farmers in North East Iceland participating in the QMS for rangeland
15 management felt that they are not given an active voice within the system, claiming that the
16 scheme is too “top down”, that there is limited consensus between different actors in relation to
17 priorities and methods, and the objectives of sustainable land use and restoration are unclear.
18 Finally, according to the findings of Stefánsson (2018) a selection of governmental employees
19 working within the governance system of rangeland management find the QMS to be lacking
20 functionality, eventually not achieving the target of halting unsustainable rangeland utilization.
21 A thorough ecological understanding derived from both scientific and traditional ecological
22 knowledge is claimed to be a fundamental pillar for sustaining an effective adaptive governance
23 system of an SES (Folke, 2006; Bark et al., 2012). We detected different understanding of what
24 sustainable rangeland management implies between the sheep farmers and the regional and
25 agricultural sectors on one hand and the environmental and the educational sectors on the other
26 hand (Table 4), indicating a knowledge gap between these sectors. It might be related to the
27 previously detected weak emphasis of programs, such as QMS, FHL and LIF, on detailing what
28 sustainability actually implies (Þorláksdóttir, 2015; Berglund et al. 2013; Petursdottir et al.,
29 2017).
30 Furthermore, the Agricultural University is the only educational institute in Iceland that offers a
31 university degree in agricultural science and sustainable land management. Thus, its academic
32 role in the transfer of scientific knowledge concerning sustainable rangeland management and
33 restoration to all studying agricultural science is of high importance. Although the majority of all

34 participants in our survey agreed that rangeland restoration should be part of the compulsory
35 curriculum for students studying agricultural science (Table 6), this is not presently the case.
36 Although rangeland management and restoration courses are taught at the AUI, the university´s
37 course catalogue shows they are optional for students pursuing agricultural science; potentially
38 leaving a scientific gap in knowledge transfer, for instance to new agricultural experts and
39 advisors, and in some cases also to new farmers.
40 Dale et al. (2013) stated argue that institutions tend to build their own culture that, in many
41 cases, creates functional silos and institutional fragmentation within the wider system. Different
42 perceptions of sustainable rangeland management detected in replies from the environmental and
43 educational sectors, on one side, and the agricultural, regionals and the farmers, on the other side
44 (Table 4), strongly indicates the existence of institutional fragmentation (e.g. Zelli, 2015)
45 between the sectors. Our results also strongly indicate that the administrative changes within the

1 system, such as the establishment of the FHL project in 1990 and the QMSQLMS programme
2 scheme in 2003, as well as the transfer of auspice competencies over environmental and
3 academic institutes agencies between ministries, have not enhanced understanding of the
4 ecological knowledge capacity understanding of on what sustainable rangeland management
5 implies involves among related stakeholder groups, in particularly within the agricultural sector
6 (Table 4). Instead, they might have even deepened the previously detected functional silos
7 between the ministries in charge of environmental and those charged with dealing with
8 agricultural issues, as well as between related institutes and organizations (Stefánsson, 2018;
9 Petursdottir et al., 2013).
10 Furthermore, the QMS scheme was intended to have positive impact on the governance structure
11 by, for instance setting the frame for improved rangeland management, based on a "Declaration
12 of Intent" made by major stakeholder groups in the year 2000 (Arnalds, 2019). The first
13 regulation on the QMS, initiated in 2003, drew upon the Declaration. The regulation was
14 revised in 2008 and again in 2013 where considerable changes were made on the QMS scheme
15 concerning the land use factor. According to a recent paper, all these regulations
16 were too lenient, not taking into account the existing ecological knowledge on the rangeland
17 systems (Arnalds, 2019). Furthermore, the SCSI—, that was responsible for verifying the
18 criteria for acceptable land use within the QMS scheme— officially objected to the content of

19 the draft of the 2013 regulation. The agency, for instance, stated that the regulation needed to
20 include more stringent rules regarding what could be considered as sustainable land use, but its
21 concerns were not taken into consideration by the agricultural minister (Arnalds, 2019). The
22 regulation was revised again in 2015 by the agricultural minister and, despite of strong
23 objections by the SCSI, the conditions for sheep farmers to achieve subsidy payments for their
24 production were extended at the cost of the conditionin trade-off with the conditions related to
25 the status of the rangeland ecosystems (Arnalds, 2019).
26
27 Effective governance systems aimed at the promotion of sustainable improved rangeland
28 management requires a well-defined organizational structures alongside an institutionalized
29 system for inter- and intra- organizational collaboration and for public/private partnerships (e.g.
30 Provan & Kenis, 2008). Our results indicate that, although more than 75% of all respondents
31 positively value share the perception that while stakeholders work on rangeland restoration
32 projects that work in close collaboration with the SCSI (Table 5), the knowledge application
33 within the SES related to sustainable rangeland management and rangeland restoration, is
34 fragmented, and not fully supporting the knowledge transfer needed, across sectors and
35 institutions. Furthermore, knowledge on how to analyze the ecological condition status of
36 rangelands in accordance with robust scientific methods seems to be mainly accumulating within
37 the environmental and the educational sectors of the system (Table 4). Although the current
38 rangeland management and restoration programs and projects, listed earlier in this paper, were
39 designed to gradually increase cross-sectoral collaboration and horizontal and vertical
40 knowledge transfer within the SES (e.g. Arnalds, 2005; Aradóttir & Halldórsson, 2012), they are
41 not co-managed in ways that would support such cross-sectoral engagement. As such, and our
42 results indicate that they have not significantly strengthened the governance process in support
43 of policy and knowledge integration (Table 6).
44 Increased institutional capacity concerning to deal with conflict resolution, as well as improving
45 the stakeholders' ability to participate in knowledge generation and in the decision-making

1 process are seen as key instruments into facilitating the transformation towards
2 adaptive governance (Brunner et al., 2005; Bark et al., 2012; Chaffin et al., 2014). Our results
3 indicate that the decision-making capacity for rangeland management was low (Table 4 and 6).

4 For instance, more than half of respondents claimed rangeland restoration policies were
5 unfocused and unclear in their intent. Furthermore, the content of current policies seemed were
6 deemed to be improperly poorly disseminated, within the SES as with around 40% of all
7 participants in the survey were not sure how to reply to questions related to rangeland´s
8 restoration policies and the majority of the respondents them were not sure who participates
9 in the policy making process (Table 6).
10 The officials (i.e. the parliamentarians and ministry officials) were shown to perceive rangeland
11 management and restoration activities through a different lens than the other sectors. Compared
12 to the other sectors, they were significantly more in favor of the view that rangeland
13 administration should be undertaken at the national rather than regional level, and of the view
14 that the government design rangeland restoration policies in collaboration with farmers and other
15 land users. Nevertheless, there was strong support for increased cross-sectoral collaboration
16 between ministries and other administrative sections for the design and implementation of
17 rangeland management policies and for including studies on rangeland management and
18 restoration in the compulsory curriculum for all pupils studying agricultural science (Table 6).
19 The findings of Petursdottir et al. (2013) based on interviews of five key stakeholders and ten
20 sheep farmers, indicated that the Icelandic SES of rangeland management focusing on
21 restoration was not fully operational, most likely due to lack of institutional strength capacity
22 and internal coherence. Petursdottir et al. (2013) also stated found that key that
23 necessary institutional key institutional norms, arrangement, such as cooperation and
24 transparency within the Icelandic SES of rangeland management, were limited weak, with and
25 the existence of functional silos within the system was reducing the vertical and horizontal
26 knowledge transfer within the governance process. The findings introduced in this paper are
27 based on replies from 38% of all Icelandic sheep farmers (480 replies) that were member of the
28 Sheep farming association at the time the research was conducted and 47% of all public/partially
29 public employees (234 replies) identified to have a direct or indirect administrative role within
30 the governance system of rangeland management. The findings of this current research detected
31 fragmented institutional arrangements, functional silos and limited cross-sectoral knowledge
32 management transfer within the rangeland management system, revealed in this research, which
33 support are supporting the findings of Petursdottir et al. (2013). They also further emphasize,
34 emphasizeing further the need for a comprehensive governance transformation, toward for

35 instance adaptive governance, to achieve sustainable rangeland utilization within the SES of
36 rangeland management and –restoration in Iceland.
37
38 **Conclusion**
39 Our results strongly indicate that the current administrative structure hasn´t significantly has not
40 facilitated either the expected attitude changes within the agricultural sector or among local
41 authorities nor behavioral changes among sheep farmers towards improved sustainable rangeland
42 management, in line with current agricultural and environmental policy targets. Furthermore,
43 they support previous findings that the governance system for rangeland management in Iceland
44 is structurally limited and partially dysfunctional. This negatively affects the potential of the
45 administrative potential of the system to implement and sustain the practices of sustainable
22
1 rangeland management among sheep farmers and other land users. The loose complex and
2 highly fragmented structure of the agricultural administration, as the map of political and
3 administrative structure of the governance system shows, the exclusion of the MENR and its
4 agencies from the policy process, and the lack of direct access of the farmers'
5 business interest organizations (FA) to the policy and decision -making process within the MII
6 concerning rangeland management need in particular to be addressed. considered carefully in this 7 context addressed. In addition, attention needs to be paid to the detected knowledge gaps related 8 to ecological knowledge transfer and use for and sustainable improved land management 9 practices. between the various public/partially public employee groups that answered our survey. 10 Furthermore, we point to the limitations arising from the lack of ano formal platform for 11 participatory forms of rangeland governance exists, leaving few opportunities for more active 12 participation and information sharing between and within the stakeholder groups, and between 13 them and the administrative districts and other institutions operating within the system of
14 rangeland governance.
15 Our results strongly indicate that, although the administration of rangeland structure within
16 the SES of rangeland management has changed gradually improved in the last 30 years, the
17 system´s institutional settings and governance practices have not adopted adaptive governance
18 approaches (AG), despite their obvious advantages advantages their processes.
19 Our findings clearly reveal the need for improved governance for rangeland management and
20 the need for increased level of knowledge application within the system. Furthermore, no
21 formal platform for participatory forms of rangeland governance exists, leaving few
22 opportunities for more active participation and information sharing between and within the

23 stakeholder groups, and between them and the administrative districts and other institutions
24 operating within the system of rangeland governance
25 To secure sustainable sheep grazing on rangelands, the related SES should be governed in an
26 adaptive way (AG) and managed toward improving and maintaining ecosystem services and
27 functions prior traditions and socio-economic interests. We thus conclude that the entire
28 governance structure surrounding the system needs to be reformed to overcome institutional
29 barriers within partly dysfunctional SESs, such as the one investigated in this research. We
30 propose a three step transformation phase in such a reform, where the first step should be the
31 establishment of a professional trans-disciplinary platform for decision making in the field of
32 rangeland management. The platform should be responsible for creating a comprehensive agri-
33 environmental policy based on an ecosystem approach and approved and accepted by majority
34 of all public sectors and other involved stakeholder groups. The second step should be to
35 actively increase cross-sectoral knowledge transfer within the system, including through local
36 involvement in all its decision-making processes. The third step should be to encourage system
37 transform towards adaptive governance and in parallel apply co-adaptive management
38 approaches with build-in regular evaluation of both the governance process and its outcomes.
39
40 **Acknowledgements**
41 This work was supported by the Energy Research Fund of Landsvirkjun and the Agricultural
42 Productivity Fund in Iceland.
43

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