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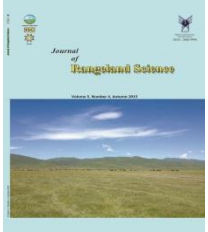

Research and Full Length Article:

Livestock Management in the Arid Zone: Coping Strategies

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Abstract. The arid zone encompasses land that has an imbalance between precipitation and losses through evaporation. Globally, arid zones comprise large part of many countries in the mid-latitudes in both the Northern and the Southern hemispheres. Both Australia and Iran are countries with a large arid zone. This negative water balance in the arid zone affects the type of land use in these countries. At the driest end of the spectrum only the hardiest livestock, camels, and some locally adapted sheep and goats provide subsistence to nomadic peoples. In other parts of the arid zone, the search for forage and water has generated development of a number of management systems involving nomadic, semi-nomadic and settled herding practices. Maximum forage productivity of livestock in the rangeland depends on the amount of water to which the livestock has access. Livestock can use the range forage in the best way with no harms to the rangeland in order to produce the maximum livestock products if there are enough water resources. Due to the limited drinking water resources in the arid regions and the range ecosystem sensitivity in these regions, the optimum use and in general, water resources management are of considerable importance. Adaptations of livestock and people are discussed here before attention is turned to the impact of livestock on the resource base that is the vegetation (principally forage/browse) and water on which the pastoralists depend.

Key words: Arid**,** Livestock management, Australia, Iran

Some terminology and definitions

The arid zone encompasses land that has an imbalance between precipitation and losses through evaporation. Globally, arid zones comprise large part of many countries in the mid-latitudes in both the Northern and the Southern hemisphere (Fig. 1).

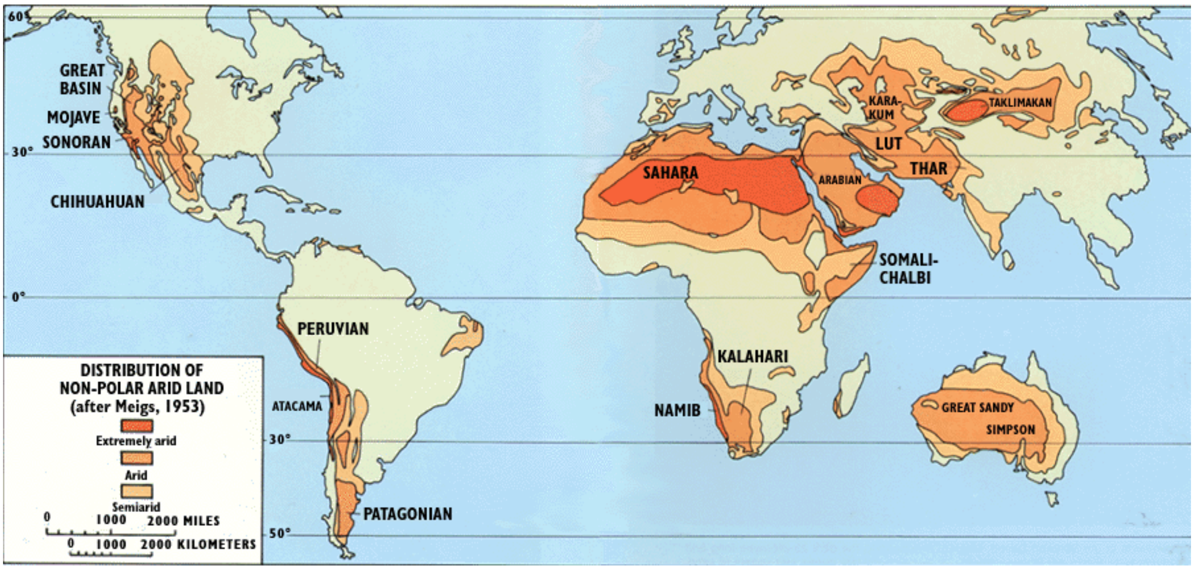

Fig. 1. World map of aridity, Darker areas are drier (Hossaini, 2012)

Strictly speaking, the various climatic zones within the broader “arid zone” have been defined on the basis of the ratio between precipitation in all its forms (rain, snow, fog and dew) and water losses through evaporation (Table 1).

Table 1. Characteristics of arid zones

Type	Dryness Ratio*	Precipitation (mm)	Precipitation Interannual Variation	Vegetation	Land Use
Hyper arid	>10	Very low(<25)	100% or more	Very little none permanent. Some after rain or dew	Oasis culture. Nomadism
Arid	7-10	From 80-150 to 200-350 low humidity	50-100%	Sparse. Found in water channels	Pastoralism. No farming unless irrigated
Semi arid	2-7	From 300-400 to 700-800 with summer rains. From 200-250 to 450-500 with winter rains	25-50%	Savannah or steppe grass. Some thorny shrubs	Rainfed cultivation and sedentary livestock
Sub humid	<2	Abundant with usually more than six humid months	<25%	Grasses and woodlands	Rainfed cultivation and industrial crops

Notes: *The dryness index is based on the ratio of rainfall and evaporation. *The inter annual variability is a measure of the deviation (+ or –) from the long term average. The higher the variability the more risky the environment

Iran has much land within the arid zone (Fig. 2) and millennia of experience in survival under such conditions have evolved into a body of local ecological and animal husbandry knowledge. Only the hardiest people and livestock can exist in the harsh conditions in the hyper-arid regions. Adaptation of people and livestock has played an important role in the survival of desert culture and assured livelihoods.

A key to successful animal husbandry in the arid zone is the development of herding systems that optimize the utilization of forage and water–two elements on which all animal husbandry depends.

Fig. 2. Iran has large areas of desert such as Dasht-e Kavir and Dasht-e Lut

Herding systems

Nomadic

The most ancient system (often involving long-distance, transboundary migration is the truly nomadic system where people and their livestock are frequently ‘on the move’. These are the nomadic peoples such as ‘Kouchadeh’ in Iran/Afghan who have no permanent settlements but move with their portable housing and their life support systems (Fig. 3).

Some migrations cover over 1000 km. Particular tribes has specific migration routes which they follow most years. Apart from nomadic system that are practicing in Afghanistan and Baluchistan, it is now observed that this system has given way to other systems (see below)

Fig. 3. Some nomadic people and their livestock move frequently to search for forage and water. They take their portable houses with them

Semi-nomadic

Semi-nomadic systems have similar attributes to nomadic but may involve a permanent home base. Many just simply move around a central encampment. Economic individualism has meant that individual members of particular tribes decide both whether to go on migration, and, if so, where. A combination of the use of vehicles to move flocks, the rise of detribalized producers with no respect for traditional system of grazing rights, and use of modern communications to establish areas of potential grazing, have all combined to produce a considerably fragmented system of migration. It is perfectly possible to be semi nomad and also to have farmland that can provide winter feed. This is because it is easy to rent both land and agricultural labor. It is also possible to be a nomad who takes flocks and herds away and to have a family with a farm and children going to school. Indeed, because of the practice of having more than one wife, some pastoralists maintain two distinct families with two distinct lifestyles.

Transhumance

Typically migration is seasonal and altitudinal (up and down mountains) so called "vertical migration). Often this involves 3-4 seasonal pastures and over-wintering in the more sheltered areas in the lowlands. Spring-autumn pastures are in the transitional hill slopes and are used on the way to and from the summer pastures at high altitude. A typical example is shown in Fig. 4.

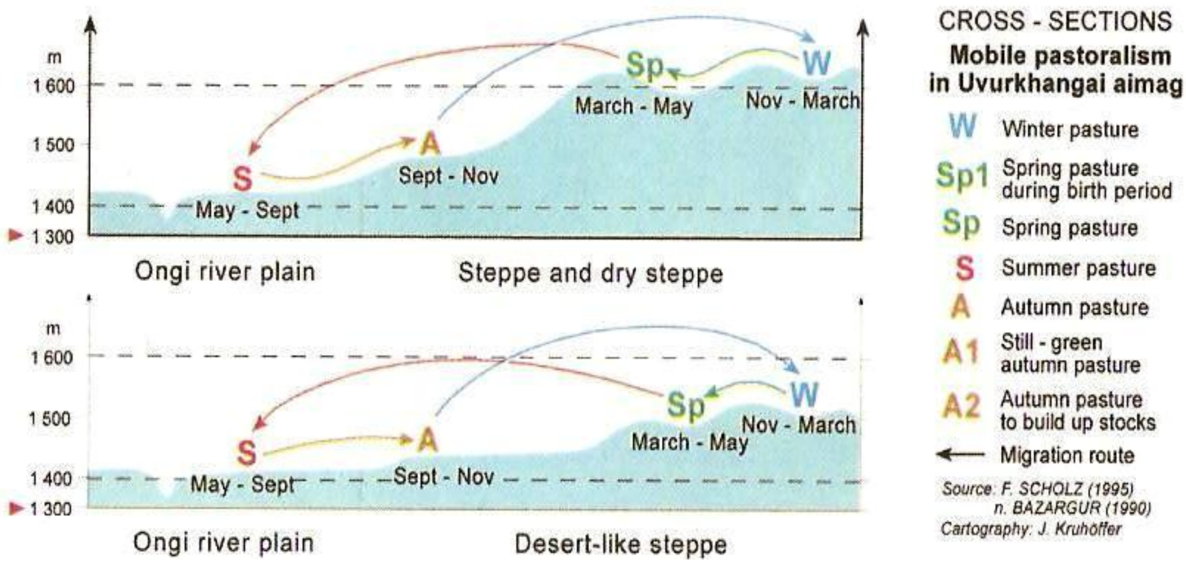

Fig. 4. A typical example of transhumance from Mongolia

As pressure from government and from the transition to the market (cash) economy increases there is a move to make pastoralists settle down. This is partly justified on the ground of ease of delivery of government services (health clinics, veterinary care, schooling and social welfare). However, it requires a massive adjustment to culture and traditions. Various schemes have been put forward. Shang *et al.*, (2015) have developed and tested such a scheme in the Tibetan plateau of China where traditionally pastoralists have no fixed settlements. In the new scheme, there are two fixed locations for each household (Fig. 5).

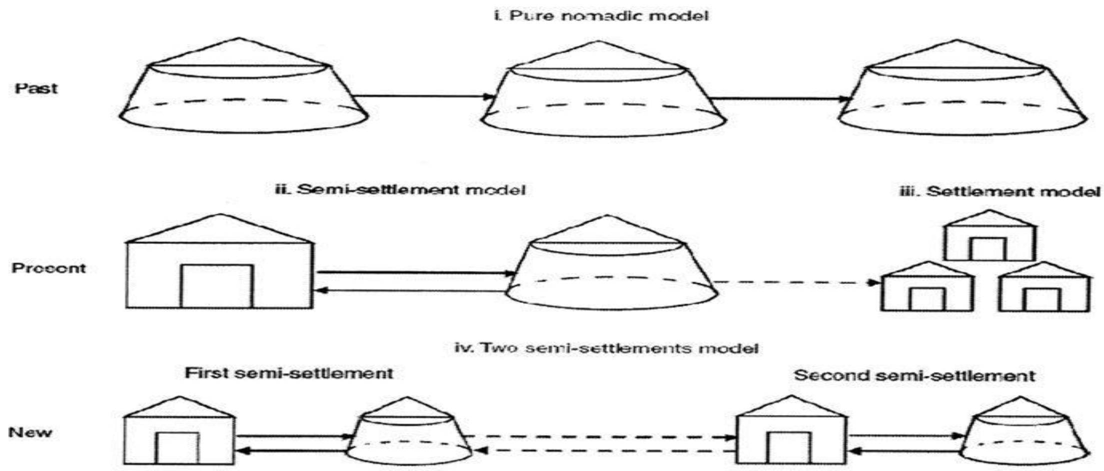

Fig. 5. The historic, present and proposed 'new model' of nomadic rangeland-livestock herders' settlements

Notes: In the pure nomadic model (i) the frequency of movement and duration of encampments depend on rangeland conditions (forage/water). In the semi-settled model (ii) having spent the winter in permanent accommodation, herds and their livestock move to higher elevation pastures for several months whiles some family members travel to find alternative incomes in urban areas (iii) as migrant day labor. The proposed two-settlement model (iv) involves households moving between two permanent and semi-permanent sites for periods of 3 to 5 years, depending on rangeland conditions. (After Shang *et al.,* 2014)

Adaptation of people/livestock to arid zones

Pastoralists have developed systems to mitigate the impacts of drought and other arid and semi-arid hardships and they range from; migration, livestock splits, reciprocal grazing and livestock loaning to and from parts of the tribe/family who live far away. Pastoralism is a subsistence pattern in which people make a living through tending livestock. For the livelihood to thrive they require a regular supply of pasture and water. The animals tended by pastoralists can provide an adequate supply of animal proteins required by humans. With the right support the pastoral economy can thrive and contribute to the national economy.

The production of livestock remains a crucial element in the economies of many countries, including Iran, with its substantial arid zone. Where the rainfall is extremely patchy and forage resources must be exploited opportunistically, the producer with a high level of mobility can maintain a herd in land that is almost unusable for fixed territory or ranch production. Moreover mobile pastoralists do not have to pay any of the fixed costs associated with fenced pastures and grazing is thus essentially a free resource. Mobility was a perfectly rational strategy in regimes of variable rainfall and that the subsequent structural instability of social groups was a regrettable but predictable result of curbing this in various government schemes that favoured more sedentary systems. When practiced sustainably, pastoralism also encourages plant and landscape diversity. When pastoralists use native livestock breeds and relies on mixed fodder types, a number of benefits are realized for plant and landscape diversity.

To provide for the needs of the populations, herding societies have developed complex management strategies. These involve keeping a herd of different species with a composition and size which can provide for the various requirements of the community. The herd must be of a size sufficient to meet subsistence needs, needs associated with trade and social obligation and to allow for a risk factor to cope with the effects of disease and trade.

This herd must have access to an area which provides grazing and water throughout the year without endangering the long-term productivity of the land resources. To be successful there is reliance on specially adapted ecotypes (local breeds) of livestock that can endure tough physical conditions (heat, cold, thirst) have great walking ability and endurance (see b).

a. Livestock genetic resources

Concerns have been raised in recent years over the loss of agricultural biodiversity through homogenization of agricultural production systems (FAO, 2007). For crop and livestock genetic diversity, two major concerns are the increasing levels of genetic vulnerability and genetic erosion (FAO, 2007).

Genetic vulnerability occurs where a widely used livestock ecotype is susceptible to a pest or pathogen that threatens to create widespread losses. Genetic erosion is the loss of genetic resources through the extinction of a livestock ecotype.

The main cause of genetic erosion is the replacement of indigenous breeds with 'improved' ones. Animal genetic diversity is critical for food security and rural development, as it allows farmers to select stock or develop new breeds in response to changing conditions (Hoffmann *et al.,* 2010).

Local breeds are commonly used in pastoral and small-scale mixed crop-livestock systems. Given the mobile lifestyle of many livestock keepers in the arid zone, the same breed often occurs in more than one country.

b. Heat stress

High ambient temperatures compromise reproductive efficiency of farm animals in both sexes and hence affect milk and meat production. There is a range of thermal conditions under which animals are able to maintain a relatively stable body temperature through behavioural and physiological mechanisms. Heat stress includes not only temperature and solar radiation, but also humidity and wind speed. Adjustments for humidity can be made using the temperature-humidity index which has been adapted for use in the livestock safety index. The temperature–humidity index be used as an indicator of thermal climatic conditions.

This index is calculated from the relative humidity and the air temperature of a particular day according to the equation defined by Kadzere *et al.,* (2002) (Equation 1):

$$THI=0.72\ (W+D)+40.6 \qquad \text{(Equation 1)}$$

Where

THI=temperature–humidity index

W =wet bulb

D =dry bulb temperature in °C

Adjustments for solar radiation and wind speed have been also developed and should be considered when predicting heat stress. Adaptation of local breeds includes resistance to high temperatures. Higher temperatures tend to reduce animal feed intake and lower feed conversion rates (Rowlinson, 2008). Heat stress can also affect the early developing embryo. Squires (1980) discuss impact of climatic factors on heat loads in summer. Core temperature can rise under the influence of the hot sun and activity such as walking while grazing or trekking to water.

An example is given of the heat balance of an adult ram (Fig. 5). Similarly, in upland areas such as the Pamir's and the Qinghai-Tibet Plateau cold tolerance developed by yaks and such breeds as Tibetan sheep is a vital adaptation in both the livestock and the people who depend on them (Ding *et al.*, 2014؛ Kreutzmann, 2013).

c. Drinking water

Water has several important functions in the animal body such as regulation of body temperature, elimination of waste products from the body via urine, feces, and respiration; transport of nutrients and other compounds into and out of cells; electrolyte balance in the body; and as a fluid environment for the developing foetus. Water is needed to make saliva for swallowing feed and for chewing.

In addition, a milking cow needs water for milk production. Domesticated animals can live about sixty days without food but only about seven days without water. Livestock should be given all the water they can drink because animals that do not drink enough water may suffer stress or dehydration. Water is especially important when livestock have a saline diet and/or saline drinking water (Squires, 2015).

The range of water turnover rates in four livestock species is shown in Table 2. Camels have the lowest turnover, zebu cattle and sheep have comparable rates. Large animals with a lower metabolic rate per unit weight and a low surface-to-volume ratio would be expected to have correspondingly low water turnover rates, and in this respect cattle appear to be the least efficient users of water.

Water turnover, however, is low in camels relative to cattle and varies inversely as the fat content relative to body weight. Goats native to tropical areas seem to have a lower water turnover rate, 11 per cent lower than sheep at high temperatures. Experimentally, camels at rest in Sahara and in central Australia maintained adequate functions during 10-15 days without water when daily temperatures reached 39-42 ^{0}C. Aspects of the physical architecture of the camel that fit it for desert life are the wide range of plants (including halophytes) that it will eat, its heat stage capacity, its reflectance summer coat, local storage of energy as fat in its hump, and conservation of nitrogen. But the distribution and turnover of water and functions of kidney and gut in relation to water and electrolyte handling are features critical to survival in water scarce areas.

Because of different degrees of fatness (body solids) it is useful to rank the animals by mol/l.$^{0.82}$, which relates to the number of molecules passing through the size-adjusted volumes of body water.

Table 2. Turnover rates of four livestock species*.

Animal Type	Turnover Rate (ml $kg^{-1}d^{-1}$)
Dromedary Camel	37–74
Bos indicus cattle	70–197
Bos Taurus cattle	9-230
Mutton Sheep	74–200
Desert sheep	65-130
Goats	90- 170

* There is a linear relationship between the log of body-water pool and the log of water turnover, the regression being: Water turnover (1 d¹) = antilog [0.836 log body water (1) – 0.619]

d. Diet selectivity. What livestock choose to eat?

Diet selectivity is important as it influence nutritional plane and can also minimize impacts of saline feed stuffs and avoid heavy loads of anti nutritional materials or toxins (Squires, 1982c). Livestock are extremely selective in what they eat. Given a choice of different species of plant they will choose some in preference to others and select *parts* of plant (Squires, 1982a). The diet chosen can bear little resemblance to the botanical composition of the plants on offer based of the each region (Fig. 6). Pastoralists can exploit the dietary preferences of different livestock types by running mixed herds/flocks. Dietary overlap can vary from a situation where limited overlap occurs to situations where the plant species chosen (but not necessarily the proportion) is the same for two or more livestock types (Squires, 1982 b).

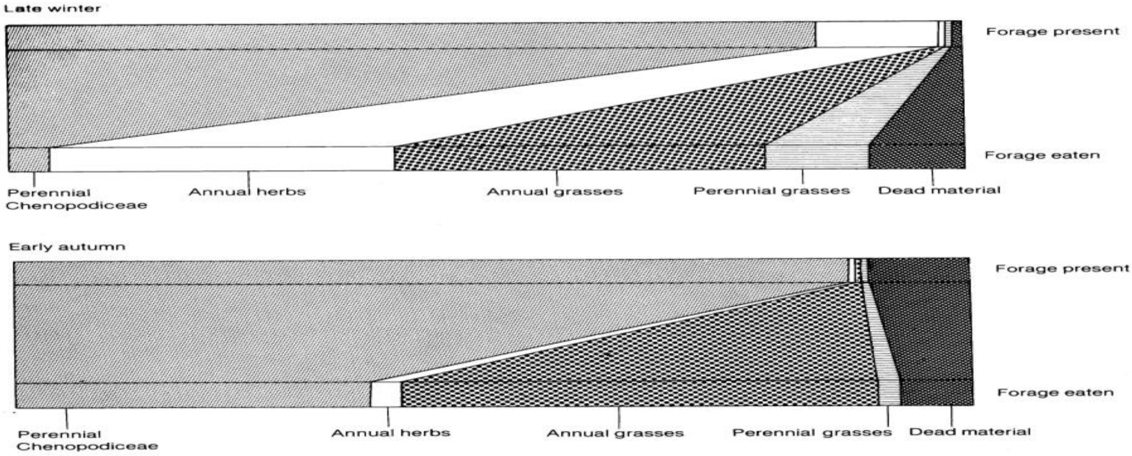

Fig. 6. The proportion of a plant in diet chosen by grazing animals may little resemblance to that on offer. Differences in phenology as well as time of year make a difference too.

Halophytic and salt tolerant species are a common feature of the arid zone and around saline depression e.g. on eastern side of the Caspian Sea that has a rich halophytic flora (Heshmati, 2013). High levels of salt intake associated with saline vegetation and drinking water pose special problems for nutrition physiology, reproductive success and the quality of animal products (milk, meat, wool and hides) (El Shaer & Squires, 2015).

Impact of livestock on forage resources

Grazing/browsing livestock can do much to change to the resource base. Their impact includes removal of biomass, trampling, and nutrient cycling. The interaction between trampling and runoff and soil erosion is clear. Micro-terracing that results from hoof action as grazing animals graze along the contours is serious problem.

a) Biosphere effect

Prolonged heavy grazing can lead to accelerated land degradation. A feature in arid zones is the development of a pattern of tracks and a halo of bare land within a short radius of a watering point (Fig. 7). The phenomenon of this radial pattern of tracks and loss of vegetation near the water source is called the biosphere and relies on the fact that the area within a given radius of the water point is based on the square of the distance. So, there are only 314 ha within 1 km radius but 5024 ha within 4 km radius (Fig. 8). Distance grazed out from water and the frequency of drinking determines grazing pressure (Squires, 1980).

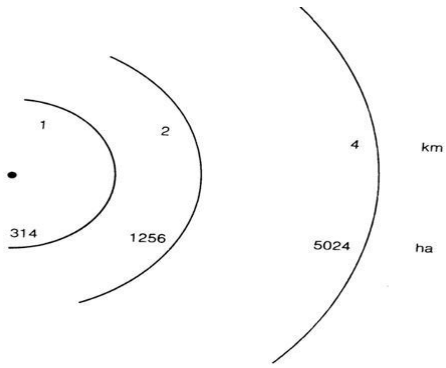

Fig. 7. The area of land within a given radius of the water point varies as the square of the distance from the water. The black dot in this diagram represents the location of the watering place.

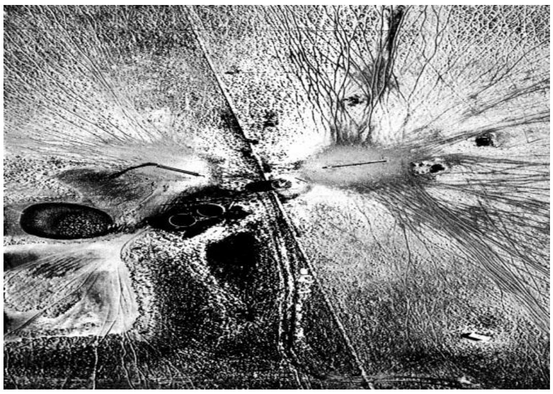

Fig. 8. Aerial view of the track patterns created by sheep radial to a water point

b) Shifts in botanical composition

The impact of livestock on the vegetation is well documented and the sequences involved in rangeland degradation and recovery are well known (Squires *et al.*, 2010). Some livestock species (goats) are reputed to be more damaging than others (cattle). Part of the effect comes from selective grazing (see above) and part from hoof action that leads to soil compaction, reduction in water infiltration rate, and other changes to soil structure and soil/water relations.

b.1. Invasion of toxic and unpalatable plants (including some alien plants)

As the impact of heavy and prolonged grazing/browsing continues there is greater likelihood of an increase in the proportion of unpalatable, and sometimes toxic, plants can occur. Invasion by alien plants from other areas may also be hastened as "openings" occur in the rangeland communities (Mangold *et al.*, 2010).

b.2. Thickening up of shrubs

Shrubs typically become dominant in rangelands that are subject to heavy and continuous grazing pressure; sometimes to the point where all useful grazing browsing is lost. Examples have occurred in New Mexico, USA where creosote bush *Larrea* spp. and mesquite *Prosopis* have rendered useless millions of hectares. Other examples are to found in Mangold *et al.*, (2010).

Summing up and Conclusions

Management of livestock in arid areas represents a number of key challenges. Livestock need feed and water. This is an inexorable demand and one that, over centuries, has given rise to development of herding systems that tried to ensure a supply of feed and water. The physical environment is often harsh (very hot or very cold – depending on arid zone conditions) and the physiological stress on livestock and people is high. These stresses influence productivity and reproductive success.

As countries develop, and the transition to the market economy goes on apace, the old paradigms no longer satisfy the needs. There is a challenge for rangelands researchers and scholars to devise new paradigms that are more relevant to today's conditions.

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دامداری در مناطق خشک: راهبردهای مقابله

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چکیده. مناطق خشک در برگیرندهٔ بخشهایی از کرهٔ زمین هستند که در آنها بین میزان بارش و هدر رفت آب از طریق تبخیر، عدم تعادل وجود دارد. مناطق خشک جهان شامل بخشهای وسیعی از کشورها در عرض‌های میانی نیمکرهٔ شمالی و جنوبی هستند. هر دو کشور استرالیا و ایران دارای مناطق خشک وسیعی‌اند که موازنهٔ منفی آب در آنها روی نوع استفاده از اراضی مؤثر بوده است. در طیف انتهایی خشک‌ترین بخشها، فقط دامهای مقاوم به‌خشکی مانند شتر وجود دارند و در بعضی از مناطق بزها و گوسفندان بومی سازگار به محیطهای خشک نیز وجود دارند که با زندگی معیشتی عشایر انطباق دارند. برای سایر بخش‌های مناطق خشک، جستجو برای یافتن علف و آب، نظامهایی از مدیریت را دیکته کرده که در برگیرنده شیوه‌های شبانی، نیمه شبانی و دامداری ساکن است. بهره‌وری حداکثر دام از علوفه مرتع، به مقدار آبی (مستقیم یا غیر مستقیم) که در اختیار دام قرار می گیرد، بستگی دارد. تنها در صورت وجود آب کافی و مناسب است که دام می تواند از علوفه مرتع حداکثر استفاده را داشته و به مرتع آسیبی وارد نشود و از این طریق حداکثر فراورده دامی تولید شود. به دلیل محدودیت منابع آبی قابل شرب در مناطق خشک و نیز حساسیت و شکنندگی اکوسیستم‌های مرتعی این مناطق، استفاده بهینه و به طور کلی مدیریت منابع آبی در این نواحی، بیش از هر منطقه دیگر ضروری می‌باشد. در این مقاله قبل از توجه به اثرات دام روی منبع پایه یعنی پوشش گیاهی (عمدتاً علف و بوته) و آب (که زندگی عشایر به آنها وابسته است)، سازش دام و انسان مورد بحث قرار گرفته است.

کلمات کلیدی: خشکی، دامداری، استرالیا، ایران