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Research on the most sustainable livestock carrying capacity in grassland management

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Introduction

Although the concept of livestock carrying capacity is highly controversial (Gillson and Hoffman 2007; Roe 1997), it is still used as the key index for grassland management, especially in China. 'X city' which has enacted a Livestock and Forage Balance Policy (LFBP) since the beginning of this century as part of a trial to test the effectiveness of the policy. The LFBP Implementing Rule in 'X city' (Trial Implementation) developed in 2002 was designed with the purpose of trying to adjust the utilization of grassland based on a pre-determined livestock carrying capacity (LCC). We collected information on the LCC adopted by herders LCC and the LCC determined by local government in 'X City' to determine which LCC was more like to be sustainable, given that sustainable management by definition must be economically viable, ecologically sensible and socially acceptable.

[**Editor's note:** given some sensitivity of the research the city and county locations have not been disclosed]

Methods

We surveyed herders in 'SY County' of 'X City' in 2009 and 2012. In 2008, we randomly selected and interviewed 20 herder households in 'SY County' using a semi-structured questionnaire to establish a baseline dataset. In 2009, we surveyed another 20 herders from two representative villages while in 2012, we interviewed 17 herders attending a Nadam Fair in 'SY County' who were willing to take a short survey as well as 6 more herders in a rural survey. In 2007 we used the household survey to establish the LCC determined by the Implementing regulation whereas in 2008 and 2011 the local LCC was obtained

through direct interview of local officers.

Results

In 2007, the LCC established by local government was set at a level less than half that which herders thought the LCC should be (Table 1; Paired t test, degrees of freedom=15, $t=14.39$, $P<0.001$). Over the survey period the LCC of herders did not change, averaging 2.36 ha/sheep unit from 2007 to 2011 (Table 1). In general, the scientific LCC (sometime referred to as the ecological carrying capacity) is determined only by the usable forage available from natural grassland. However, in practice, the ecological LCC was too restrictive because it does not take into account the total stock of all forage sources such as artificial pastures (*e.g.* alfalfa, milk vetch and sainfoin), crop residues that are grazed following grain harvest or fed as stover supplement or purchased forage and concentrates. Based on audits of the use of these additional feed sources by herder households, livestock experts have developed an adjusted LCC which aligns better with the standing LCC (Fig. 1).

The standing LCC is calculated as the yearend livestock numbers divided by the grassland area. However, the adjusted LCC are not accepted by the local government, despite the logic of determining LCC based on the total forage available rather than just considering grassland production. A detailed livestock census carried out in 'SY County' in 2009 showed that the standing LCC increased from 4 ha/sheep unit (2005 through 2008) to 2 ha/sheep unit in 2009 (Fig. 1) which was similar to the herder LCC indicating that grasslands were being grazed at almost 4 times the standard local government LCC (Fig. 1). This means that herders would have to significantly reduce their livestock number to utilize grassland at the local LCC.

Table 1. Different LCC standards obtain from interviewed herders.

Variable surveyed	Herders Surveyed	Mean (ha/sheep unit)	Standard Deviation	Mean (sheep unit/ha)
Local LCC in 2007	18	5.60	0.77	0.18
Herder's LCC in 2007	24	2.61	0.52	0.38
Herder's LCC in 2008	20	1.89	0.56	0.53
Herder's LCC in 2011	21	2.59	0.82	0.37
Herder's LCC of 666 ha	21	1.54	0.83	0.65

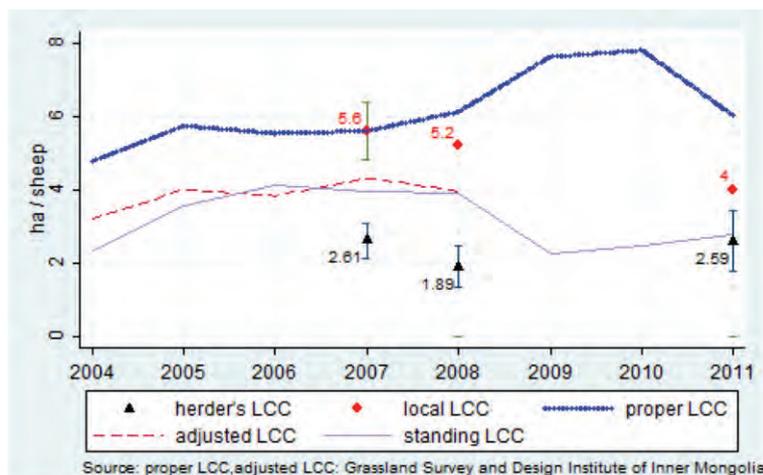


Figure 1. Comparison of different carrying capacity standards.

Discussion

One important outcome of this study was to better understanding whether livestock number or production efficient production/forage unit is key driver for herder sustainability. From the survey results it is clear that numbers rather than efficiency influence their management decisions. This is shown another interview question that asked how many livestock would you breed if you had a 666 ha of typical grassland; the mean of the replied was 433 sheep or a LCC of 1.54 ha/sheep which is effectively a grazing intensity twice that of the current the current herder LCC (Table 1). This means that grasslands would degrade more rapidly if the grazing area per household was significantly increase, unless they were prepared to secure large quantities of hay, stover and concentrate to supplement the dry matter produced form grasslands. This desire by herders to increase livestock number reflects the price of sheep which has been rising at astounding rate since 2011. However, since the market is starting to differentiate with higher prices paid for better quality, it remains too been seen if simply increasing numbers is more profitable than producing fewer animals of higher quality. In addition to continuation of LCC can only be sustained with higher inputs of artificial pasture and crop residues. Otherwise there is a high risk of irreversible degradation of grassland.

Conclusion

Generally, both the proper LCC and the LCC determined by local government appears to restrictive to determine sustainable carrying capacity of typical grasslands in SY County because they only take into account forage supplied by grassland whereas the adjusted LCC better reflects the balance between livestock numbers and the total of all forage sources available. The close correlation

between the adjusted LCC and the standing LCC indicates that non-grassland sources current provide a significant amount of the nutrition of sheep in SY County. However, while the local government has gone some way toward closing the gap between the ecological LCC and the standing LCC by reducing their local LCC from 5.6 ha/sheep of 2007 to 4 ha/sheep of 2011 (equivalent to increasing stocking rate from 0.18 to 0.25 sheep units/ha), the local LCC was always more conservative than the herder LCC and would require herders to reduce their sheep flock size to conform to the local LCC. In practice, since grassland productivity declines with increasing stocking, continuation of the herder LCC over the medium- to long-term will change significantly the dominant species and functional group components of the grassland thereby reducing sustainability, unless the amount of non-grassland forage resources are significantly increased. The fact that herders indicated that they would increase their stocking rate significantly if they had a larger area of grassland suggest little commitment by herders to secure more non-grassland feed supplies. Taken on balance this suggests the local LCC would be a better rate to use than the herders' LCC to make grasslands more sustainable in SY County.

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