Supplementary information to Wilkes, A., Wang, S., Lipper, L. and Chang, X., Market costs and financing options for grassland carbon sequestration: Empirical and modelling evidence from Qinghai, China.

**Table S.1: Herd model input parameters used to simulate the response of household livestock yields to imposition of stocking rate limits in each scenario modelled**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Maximum weight at maturity (kg)** | | | | **Birth weight (kg)** | | **Birth rate** | | **Survival rate** | | **Adult mortality rate** | | **Total SU per farm** |
| **Scenarios (destocking rate)** | **Cow** | **Bull** | **Ewe** | **Ram** | **Calf** | **Lamb** | **Yak** | **Sheep** | **Calves** | **Lambs** | **Yak** | **Sheep** |  |
| Baseline (0) | 210.6 | 326.4 | 29.8 | 38.7 | 50 | 3 | 0.66 | 1.14 | 0.9 | 0.9 | 0.02 | 0.04 | 207 |
| **Year 1-10 Scenarios:** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Scenario A (.29) | 279.7 | 433.5 | 47.3 | 61.4 | 50 | 3 | 0.66 | 1.14 | 0.9 | 0.9 | 0.02 | 0.04 | 147 |
| Scenario B (.38) | 271.2 | 420.4 | 48.2 | 62.6 | 50 | 3 | 0.66 | 1.14 | 0.9 | 0.9 | 0.02 | 0.04 | 128 |
| Scenario C (.47) | 255.2 | 395.5 | 49.6 | 64.5 | 50 | 3 | 0.66 | 1.14 | 0.9 | 0.9 | 0.02 | 0.04 | 110 |
| Scenario D (.56) | 242.3 | 375.5 | 50.5 | 65.7 | 50 | 3 | 0.66 | 1.14 | 0.9 | 0.9 | 0.02 | 0.04 | 91 |
| Scenario E (.65) | 223.7 | 346.7 | 51.7 | 67.2 | 50 | 3 | 0.66 | 1.14 | 0.9 | 0.9 | 0.02 | 0.04 | 73 |
| **Years 11-20:** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Scenarios A-E | 293.9 | 455.6 | 44.7 | 58.1 | 50 | 3 | 0.66 | 1.14 | 0.9 | 0.9 | 0.02 | 0.04 | 226 |

Notes: kg: kilogram; SU: sheep units

**Table S.2: Soil carbon sequestration rates for land under different management practices in each with-project scenario modelled**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Initial degradation status** | **Baseline land use** | **With-project land use** | **With-project biomass removal rate** | | **SOC sequestration rate (tC ha-1 yr-1)** | |
| **Years 1-10** | **Years 11-20** | **Years 1-10** | **Years 11-20** |
| Light | Warm season grazing | Warm season grazing | 50% | 50% | 0.06 | 0.06 |
|  |  |  | 40% | 50% | 0.40 | 0.06 |
|  |  |  | 30% | 50% | 0.56 | 0.06 |
|  |  |  | 20% | 50% | 0.60 | 0.06 |
|  | Cold season grazing | Warm season grazing | 50% | 50% | 0.004 | 0.06 |
|  |  |  | 40% | 50% | 0.03 | 0.06 |
|  |  |  | 30% | 50% | 0.04 | 0.06 |
|  |  |  | 20% | 50% | 0.04 | 0.06 |
| Moderate | Warm season grazing | Warm season grazing | 30% | 50% | 0.96 | 0.06 |
|  |  |  | 20% | 50% | 1.04 | 0.06 |
|  | Cold season grazing | Warm season grazing | 30% | 50% | 0.08 | 0.06 |
|  |  |  | 20% | 50% | 0.09 | 0.06 |
| Heavy | Warm season grazing | Reseeded + fertilized + cold season grazing | 50% | 50% | 1.88 | 1.88 |
|  | Cold season grazing | Reseeded + fertilized + cold season grazing | 50% | 50% | 0.34 | 0.34 |
| Severe | Warm season grazing | Cultivated pasture + fertilization + cold season grazing | 50% | 50% | 1.93 | 1.93 |
|  | Cold season grazing | Cultivated pasture + fertilization + cold season grazing | 50% | 50% | 0.43 | 0.43 |

Note: Soil organic carbon sequestration rates estimated using Century 4.5 validated for the project site as described in Chang, X.F., Zhu, X.X., Wang, S.P., Cui, S.J., Luo, C.Y., Zhang, Z.H. et al. (2014). Impacts of management practices on soil organic carbon in degraded alpine meadows on the Tibetan Plateau. *Biogeosciences*, 11(13), 3495-3503; doi:10.5194/bg-11-3495-2014

**Table S.3: Transaction cost components and cost assumptions used in analysis of market costs of carbon sequestration**

|  |  |
| --- | --- |
| **Cost components** | **Assumptions and costs (CNY)** |
| **Project development costs** |  |
| Identify sites | Invariant to project scale; CNY 72,324 |
| Draft project concept | Invariant to project scale; CNY 210,924 |
| Design individual farm plans | Varies with scale; CNY 1,270 per day, 5 households per day + analysis costs |
| Project area baseline & emission reduction estimation | Invariant to project scale; CNY 189,000 |
| Monitoring system design | Invariant to project scale; CNY 72,527 |
| Draft project design document | Invariant to project scale; CNY 160,650 |
| Environmental impact assessment | Invariant to project scale; CNY 80,000 |
| Buyer-seller negotiation | Invariant to project scale; CNY 20,000 |
| Draft legal contracts | Invariant to project scale; CNY 100,000 |
| Project document validation | Invariant to project scale; CNY 315,000 |
| **Project implementation costs** |  |
| ***Initial set-up costs*** |  |
| Signing contracts with households | CNY 800 per day; 10 households per day |
| Training in monitoring methods | Invariant to project scale; CNY 28,700 |
| Office equipment | Invariant to project scale; CNY 8,000 |
| Monitoring equipment | Grass biomass monitoring equipment invariant to scale (CNY 16,000), GPS increase with scale (CNY 3,000 RMB per 25 households) |
| ***Annual monitoring costs*** |  |
| Staff costs | CNY 42,000 p.a. up to 400 households, CNY 84,000 above 400 households |
| Implementation agency management fee | 5% of total monitoring costs |
| Annual grassland management plan | CNY 710 per day \* 1 day for 5 households |
| Grass planting monitoring costs | Sample 5% of plots; 5 plots per day, CNY 710 per day |
| Community monitoring meetings | 2 per year; CNY 1420 per meeting, 1 meeting per 25 households |
| Community monitors’ honorarium | CNY 6000 per person p.a., 3 persons per 25 households |
| Implementation agency sample survey costs during grazing seasons | 95±10 sampling precision; CNY 710 per day, 10 samples per day |
| Implementation agency sample survey costs at end of each grazing season | 95±10 sampling precision; CNY 710 per day, 10 samples per day |
| Grassland biomass monitoring | CNY 8840 p.a. invariant to scale since depends on number of land use strata |
| Support for monitoring and validation | CNY 40,000 p.a. |
| ***Carbon costs*** |  |
| Verification costs | CNY 126,000 per verification event |
| Carbon credit issuance costs | CNY 0.30 per credit issued |

Notes: CNY: Chinese Yuan; p.a.: per year; GPS: global positioning system