

Appendix 1. Explanations of the formulas in Figure 2.

Figure 2 shows the decision process of amounts of livestock to sale, fodder to buy and money to borrow with different stocking strategies. With input of information of herd, usable forage on pastures, price of sheep and forage, available loan, and household cash flow, the agent will decide the amounts of livestock to sale (Q_s), fodder to buy (F_{input}) and money to borrow (L). There are three constrictions that the agent must follow: (1) all the old and sick sheep (Q_1) will be sold to maximize the future productivity of the herd; (2) The fodder supply, including the forage on pastures ($F_{pasture}$) and the fodder purchased from market (F_{input}), should be no less than the fodder demand by the herd; and (3) the available cash (including net income and loans), should be no less than expenditures (including domestic expenditures and loans to pay back).

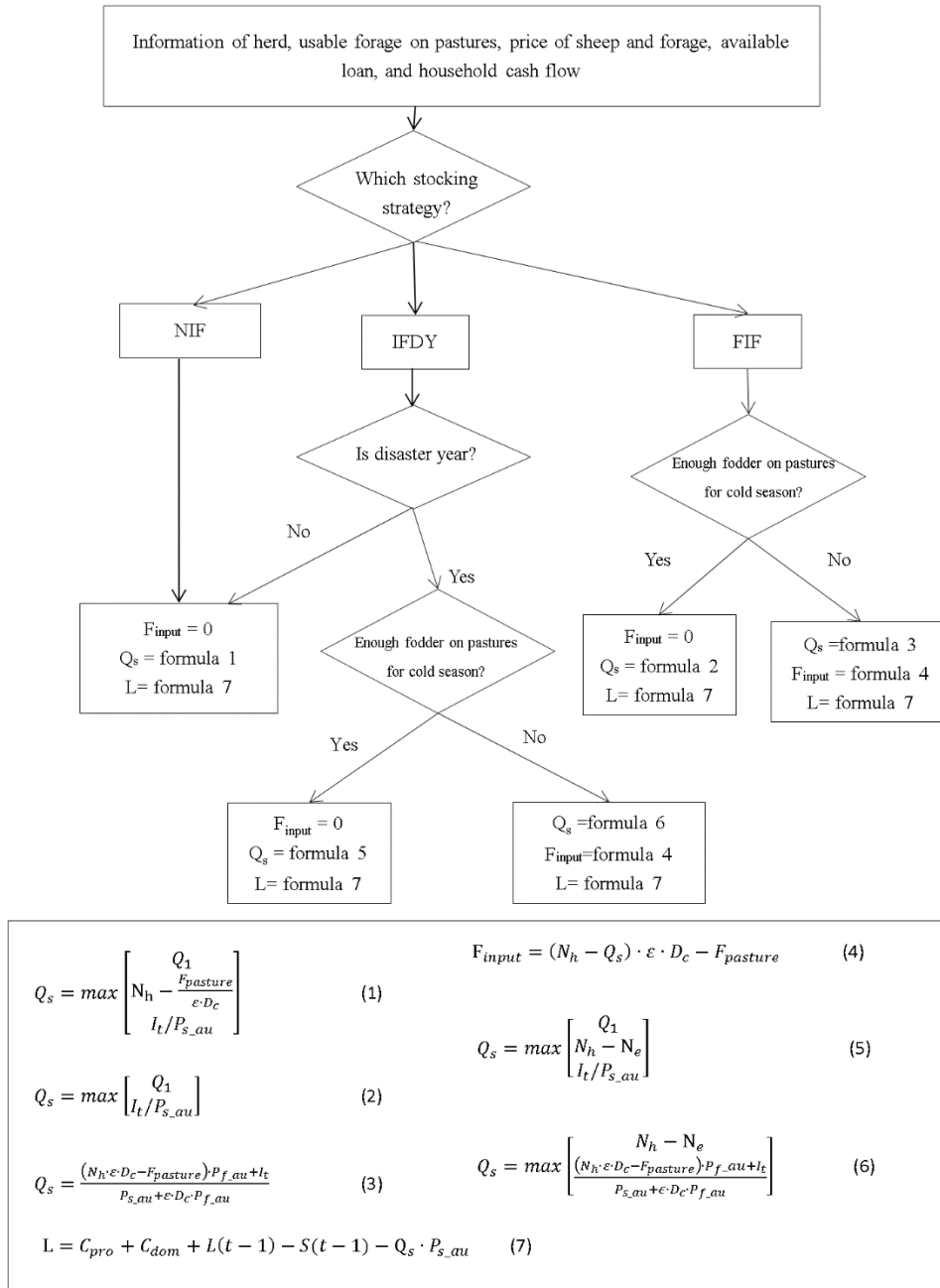


Figure 2. Flow chart of the processes of the agents' stocking decision. With input of information, the agents with different stocking strategies decide how much livestock to sale and forage to buy according to the decision process and the formulas. NIF- no import of forage, FIDY- import forage only in disaster years, FIF-import of forage whenever forage gap exist, F_{input} - amount of purchased forage, O_s - total number of sheep to sale, L -amount of money to borrow, $F_{pasture}$ - usable forage from pastures in cold season., N_h – total number of sheep, Q_1 - number of sheep to sale at first stage, is the sum of the number of the old, the sick and male lamb. ε - daily intake of a sheep, D_c – total days in cold season, I_t – target income, $I_t =$ total production costs before fodder purchase+ living expenditures + savings of the previous year+ loan (if exist) – available loan, P_{s_au} – price of sheep in autumn, P_{f_au} – price of forage in autumn, N_e - number of ewes at the beginning of the year, C_{pro} - production costs, C_{dom} - family expenditures, $L(t-1)$ – loans of the previous year, $S(t-1)$ – savings of the previous year.

Decisions with the ‘No import of fodder’ (NIF) strategy

If the ‘No import of fodder’ (NIF) strategy is adopted, no fodder will be inputted, thus, $F_{input} = 0$. The number of sheep to sale is the biggest one among Q_1 , the total number of sheep (N_h) minus the number of sheep that pastures could support ($F_{pasture}/(\varepsilon \cdot D_c)$), in which ε is daily intake of a sheep and D_c is days in cold season), and the number determined by the need of cash (I_t/P_{s_au}), where I_t is target income, which represents the amount of money that the agent have to earn to cover production costs and domestic expenditures. $I_t =$ total production costs except for fodder costs in autumn+ living expenditures + savings of the previous year + loan (if exist) – available loan, P_{s_au} is price of sheep in autumn.)

Amount of money to borrow (L) is determined by the total production costs (C_{pro}) + family expenditures (C_{dom}) + loan of the previous year ($L(t-1)$) – savings of the previous year ($S(t-1)$) – gross income from livestock sale ($Q_s \times P_{s_au}$). If $t=1$, then loan of the previous year is 0 and savings of the previous year is 20000 yuan as set during initialization.

Decisions with the ‘frequent import of fodder’ (FIF) strategy

If the ‘frequent import of fodder’ (FIF) strategy was adopted, F_{input} , Q_s and L is further determined by usable forage on pastures for cold season and fodder demand. If there are enough fodder on pastures for cold season ($(N_h - Q_1) \cdot \varepsilon \cdot D_c \leq F_{pasture}$), then the agent does not need to buy fodder, thus $F_{input}=0$. Q_s is the larger one between Q_1 and the amount determined by cash need (I_t/P_{s_au}). The amount of loan to borrow is determined by formula 7 as described in the previous section. If there is not enough fodder on pastures for the cold season, then extra sheep have to be sold in addition to Q_1 . The Q_s could be solved from the equation:

$$Q_s \cdot P_{s_au} = I_t + ((N_h - Q_s) \cdot \varepsilon \cdot D_c - F_{pasture}) \cdot P_{f_au} \quad (1)$$

in which the left is gross income from sheep sale, and the right is the total expenditures, including the costs of purchasing fodder. The amount of fodder input equals fodder gap $((N_h - Q_s) \cdot \varepsilon \cdot D_c - F_{pasture})$. The amount of loan to borrow is determined by formula 7 as well.

Decisions with the ‘import of fodder only in disaster years’ (IFDY) strategy

If the ‘import of fodder only in disaster years’ (IFDY) strategy is adopted, the agent has to follow two additional constrictions: (1) do not input fodder in normal years, (2) input fodder is

allowed in disaster years under the pre-condition that the number of breeding ewe do not increase. Therefore, if the year in question is not a disaster year, then the decision is the same as with the NIF strategy. If the year is a disaster year, the decision will be further determined by the supply and demand of fodder. If there are enough forage on pastures for cold season, then there's no need to buy fodder, thus $F_{input}=0$; Q_s is the biggest one among Q_1 , the differences of current herd number (N_h) and the number of ewes(N_e) at the beginning of the year, and the number determined by cash need (I/P_{s_au}). Otherwise, Q_s is determined by the number of breeding ewe at the beginning of the year, or the equation (1) in the appendix. F_{input} equals fodder gap. In any cases, the amount of loan to borrow is determined by formula 7.

From the above processes, it is clear that the core step in stocking decision is to determine the number of livestock to sale. The amount of fodder input and loan to borrow are determined by the remaining number of livestock.