COST BENEFIT ANALYSIS ON DZUD-2010 DISASTER PREVENTION GRANTSPROGRAMME IN MONGOLIA

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ABSTRACT

The Dzud, a climatic disaster which severely affects Mongolian herders, poses the most dangerous natural threat to the country's rural economy. The negative impacts are loss of livestock (direct impact); human health, unemployment, poverty, migration (indirect impacts). Disaster Prevention Grants Programme funded by United Nations Development Programme to help with herders to reduce future Dzud vulnerability in Dundgobi, Uvurkhangai, Khovd province. This programme is beneficial for the herders on the basis of Cost Benefit Analysis methodology. The net present value of the project is 437.5 thousand dollars in seven years. We suggest that the herders should be prepared for the Dzud by preparing shelters, and hay harvest then these activities would generate more benefits of avoiding disaster damages than the costs.

KEY WORDS: Dzud, disaster management, disaster protection program, cost and benefit analysis

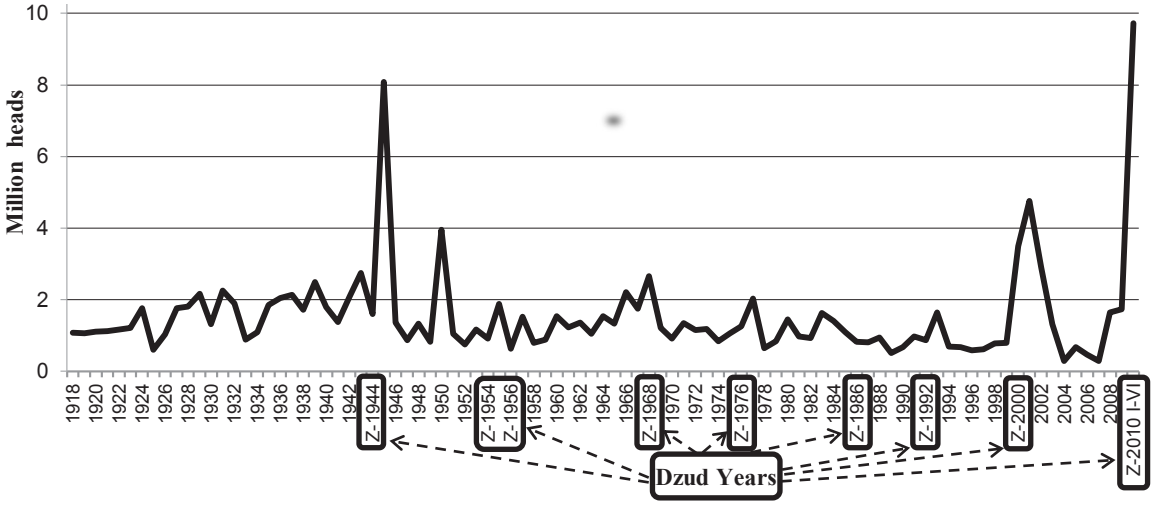
INTRODUCTION

The increasing number of natural catastrophes represents one of the prevalent problems of climate change today. The projects and policies aiming to reduce the resulting damages, impacts and risks have increased considerably, but their significance and economic benefits are often not properly taken into consideration in developing countries.
The Dzud is an extraordinarily harsh condition of coldness, a huge amount of snowfall and strong windstorms in the winter, which cause animal starvation and loss of livestock. As a consequence, herders lose their livelihood, resulting in poverty, unemployment and unplanned migration to central areas in Mongolia, see Appendix[1, 2, 3, 4].
The primary purpose of the dissertation is to examine whether the total social benefit of one such project is higher than its costs within selected provinces of Mongolia.

Negative Impacts of Dzud
Direct impacts:Loss of animals means a loss of livestock products, lack of transportation, less food consumption for herders and an inadequate amount of dried animal dung which is used for fuel for heating and cooking[5, 6, 7]. Figure 3 shows that livestock loss dramatically increased during the years when the Dzuds occurred. In 2010 the biggest number of livestock perished since 1918. According to UNDP and the Red Cross in Mongolia, the number of perished animals directly affected by Dzud 2009-2010, was 7.8 million as at the beginning of May 2010 (Appendix 1)[6].The last Dzud was the second heaviest in terms of losses after the Dzud in 1944-1945 which was estimated at 9.2 million[8, 9, 10].
Indirect impacts: **Poverty:** If a herder' s livestock perish, it leads to an increase in unemployment and poverty. Therefore it increases in household food and transportation cost. **Migration:** The

number of herders decreased by 4.2% and around 50 thousand herders migrated to the capital Ulaanbaatar in the after Dzud 1999-2001[2]. A migration survey conducted by the UN Population Fund resulted that 14% of migrants were herders who had lost all of

Figure 1.**Adult Livestock Loss in Mongolia (mln.heads)**



Source: Macro Economic and Statistical Department, NSO (2010) Unpublished raw data[11]

- NSO counts the Adult Livestock Loss that is caused by disasters, diseases etc annually.
- Adult Livestock Loss in 2010 is accounted for the first 6 months of 2010 (NSO, June 2010)[12]
- Z- denotes that Dzud occurred in that year (Ministry of Food and Agriculture of Mongolia, 2004)[8]

Their animals due to the Dzud, 1999-2001[2]. **Health and psychological impacts:** Dzud poses a high risk to human health in both in the short and long-term. Herders suffer from hunger[13]; Access to emergency health care is cut off ;some rural hospitals had to close due to inadequate heating[2]; Maternal and infant mortality rates increased[14];some herders die when they try to find their lost livestock in blizzards; Increasing diseases from died carcases of the livestock that increases water borne diseases; Psychological disorderswere seen among adults in affected areas[15].**Education:** kindergardens and schools were closed for some time due to low attendance, poor travel conditions and poor quality of school buildings[15].

METHODOLOGY

In Boardman et al., (2006), the fundamental concept of benefits and costs is based on the notion of willingness-to-pay:**Benefits (Costs)** are sums of the highest amounts that persons would be willing to pay to obtain (to avoid) outcomes that are desirable (undesirable) in their opinion [16]. Hence, Net Social Benefit (NSB) increases with benefits, and decreases with costs (Eq.1); i.e. the NSB is the difference between benefits and costs.

$$\boldsymbol{NSB = B - C} \qquad \textbf{(Eq.1)}$$

Cost-Benefit Analysis is a policy assessment method that quantifies the policy outcomes in monetary terms to all members of society; therefore net social benefit measures the value of the policy [16]. Hallegatte (2006) developed a model for Cost-Benefit Analysis of flood protection system.The expected benefit of the DPS is complex but Hallegatte suggests that the total benefit can be measured by aggregating the estimates of consequences avoided by disaster management; for example: physical injuries, economic losses and psychological trauma [17, 18]. The first step is the aggregation of these damages between different categories of impacts [19], and the second is the inter-temporal-aggregation[20]. As determined by Hallegatte (2006), the benefit function is illustrated by the present value of damages (d_n) avoided by the disaster protection system:

$$\boldsymbol{B = \sum_{i=0}^{n} p \cdot \left(\frac{1}{1+\delta}\right)^{n} \cdot d_0(1+g)^n \approx \frac{p d_0}{\delta - g};\ d_n = d_0(1+g)^n} \textbf{(Eq.2)}$$ Source: Hallegatte (2006), p.5

In equation 2, the probability of occurrence of the disaster (p) and the avoidable damage in monetary terms (d_n) are key parameters, but the social discount rate (SDR, δ) is also needed to estimate the expected benefit (B) of the Disaster Protection System to discount future benefits into the present term[17, 21]. In other words, if the disaster loss and disaster probability increases, then the total benefit of the project increases. This is the main principle of modelling the benefit function of disaster protection management. In addition, Hallegatte assumed that future losses due to disaster will increase at the same rate of economic growth [17]. The benefits of implementation depend on: first, recurrence probability; second, current loss related to the economic growth rate; and third, the social discount rate.

RESULTS

The Early Recovery Programme(ERP) implemented by the UNDP is to reduce the damage of the Dzud 2009-2010 and increase awareness and preparation capacity to avoid for future Dzuds. We analyzed only one of the four sub-programmes of ERP, which is Disaster Prevention Grants sub-Programme (DPGP). It has positive net benefit, suggesting that DPGP is beneficial to herder households in proposed provinces: Dundgobi, Uvurkhangai and Khovd (3 provinces).DPGP began in June 2010 and is intended to run until June 2011. Aim of DPGP is to improve the Dzud preparation of 4500 herder households in 3 provinces [22].

Cost of Disaster Prevention Grants Programme

The total cost of DPGP is 2.75 million USD that will be used in the CBA net benefit calculation[22]. The costs are intended to be spent for 1) providing training and grants for the improvement of winter camps for livestock; 2) restoring and protecting natural water and wells; and 3) strengthening hay and fodder storage.

Benefit of Disaster Prevention Grants Programme

DPGPgenerates direct and indirect benefits to the herders. Direct benefit is the avoided livestock loss by improving Dzud preparations, and indirect benefit is the reduction of other damages.

1. Direct benefit: Avoidable livestock loss

The Disaster Prevention Grants programme selected 4500 herder households who left with 250-500 livestock after the Dzud 2010 in 30 *soums* of the 3 provinces. Selected families were given small grants from DPGP to improve their Dzud preparation; for example, improvement of winter camps, water resource restoration, and protection from diseases. Full training of methods of preparing for the winter and protecting themselves from severe Dzudimpacts was also provided [22].

Livestock Losses Prediction

The main reasons of livestock loss are poor winter preparations, including insufficient amount of fodder, hay, and inappropriate winter camps or shelters to keep the livestock warm. Begzsuren et al., (2004) used simple time series analysis, regressing snowfall and temperature, of November and December of previous year and January and February of the current year, on livestock loss for the current year[23]. Their method is used in this paper to value the benefit of winter preparation, using monthly instead of yearly data to gain a clearer understanding of the effects of Dzud.

Model and data

The monthly Adult Livestock Loss is chosen as the dependant variable in the analysis. The National Statistical Office began to publish this data in 1997[24]. In order to illustrate the livestock loss due to Dzud, the timeline of the dataset is selected for six months from December to May; and the number of livestock losses due to diseases is subtracted from the total livestock loss. The dataset of the all variables is from December 1997 to May 2010 for 78 months (13 years x 6 month blocks) for 3 provinces. Thus, the function of livestock loss becomes:

$$\boldsymbol{loss_i = \beta_0 + \beta_1 temp_i + \beta_2 pre_i + \beta_3 days_i + \beta_4 hay_i + \beta_5 fod_i + \beta_6 dzud_i + r} \forall i \in 1,2,,3 \ldots 78 \textbf{(Eq.2)}$$

- $loss_i$– Total monthly Adult Livestock Loss (excluding livestock loss due to diseases)
- $temp_i$– Monthly average temperature (C^0)
- pre_i – Total monthly sum of precipitation (mm)
- $days_i$– Average number of days with dust and snowstorms
- hay_i– Total harvested hay in previous year (ton)
- hay_i – Total harvested fodder in previous year (ton)
- $dzud_i$-Dummy, if Dzud occurred in the month, it equals 1, otherwise 0.

Eq.2 implies that the livestock loss in winter and spring months (from December to May in the 3 provinces) are explained by: temperature; precipitation level; dust and storm days; the total hay and

fodder harvest of the previous year in the 3 provinces; and the dummy variable for whether Dzud occurred in that month. Of course, it is not possible to cover all causes of livestock loss in this regression; therefore, the error term "***r***" covers the other causes that are not explained by the model.The descriptive statistics of the data in the 3 provinces are shown in Table 1.

Table 1

Descriptive statistics of data

Variable	Unit	Mean	STD	Min	Max
Loss	(000 Heads)	73.9	158.1	0	935.4
Temp	(C^0)	-5.73	11.3	-23.6	13.2
Pre	(mm)	14.7	20.7	0.8	136.8
Days	(days)	2.59	1.88	0.0	8.7
Hay	(tonnes)	71,746	18,748	44,800	106,100
Fodder	(tonnes)	1,112	874	153	3,060
Dzud	(0 or 1)	0.32	0.47	0	1

Note: Data simulations have been used for some missing values. The data for the ***days*** variable from December 1997 to April 1998 was not reported in any NSO publications, so it is assumed that these values are equal to the average. The proxy value for corresponding months in the other years in the data set is also the average (i.e. number of days with storm in December 1997 is the average December value in the rest of the data set).

Data sources:

- Monthly statistical bulletin, NSO (2000-2010): ***loss, temp, days***[24, 25];
- Monthly climatic data for the world, NOAA (1997-2000): data of ***temp, pre*** between December 1997 and May 2000[1][26];
- Unpublished data, Macro Economic and Statistical Department, NSO (2010): ***hay***, ***fodder***[11]

From these descriptive statistics, about 73,908 head of livestock perished, and 14.7 mm precipitation fell on average per month in the 3 provinces. The monthly temperature was-5.73C^0

Table 2

Regression Results for Livestock Loss due to Dzud

Variables	β_i	St.E
Temp (β_1)	-4.773**	1.840
Pre (β_2)	1.492*	0.893
Days (β_3)	23.344**	9.336
Hay (β_4)	-0.0012**	0.001
Dzud (β_6)	159.138***	30.46
R-squared	0.487	
Adjusted R^2	0.452	
F-Statistic	13.850	
F>Probability	0.000	
No. obs	78	

*, **, *** variable is significant at 90%, 95% and 99% level, respectively.

and the average number of days with storm was 2.6 days in one province on average. The average harvested hay in the 3 provinces was 71,746 tonnes, and fodder was 1,112 tonnes on average in one year, which was prepared in the previous autumn before the winter began. The average value of the ***Dzud*** dummy indicates that the Dzud occurred for almost one third of the months in the dataset from December 1997 to May 2010.

[1] The weather stations are *Mandalgobi* in Dundgobi province, *Arvaikheer* in Uvurkhangai province, *Khovd* in Khovd province.

RESULT OF ANALYSIS

The multivariate time series econometrics model is run, illustrated in Equation 2, on the simulated data set, and the regression result is shown in Table 2 for three models.

After some simulations of the model (Eq.2) the constant, β_0, did not satisfy with 90% significance level; and variable ***fodder*** did not give the expected negative sign and it was correlated with variable ***hay*** had co-linearity problem. Thus, we excluded constant and ***fodder***from our model. The quality of model is sufficiently high to be used in subsequent calculations. P value of F-statistic shows that the independent variablesexplain the dependant variable very good as all together.

Regression results indicate that: The adult livestock loss in the 3 provinces in one month is predicted to decrease by 4,773 when the average temperature of the region increases by $1C^0$ and by 1.2 when the harvested hay of the previous year increases by 1 tonne, while other variables remain constant. On the other hand, livestock loss is predicted to increase by 1,492 when the sum of precipitation in 3 provinces increases by 1mm; 23,344 when the average number of days with dust and snow storm in the 3 provinces increases by one day; by 159,138 when the number of Dzud months increases by one.

Benefit of DPGP by increasing hay harvest and improving winter camps

The DPGP plans to improve the winter preparation of 4,500 herder households for future Dzuds by distributing grants and carrying out training to decrease the Dzud damages.

Table 3

Avoidable livestock loss per month under assumption 4 in 3 provinces

Variable		Average* value	Coefficients**	Predicted livestock loss (000 Heads)	Changed average values***	Predicted livestock loss (000 Heads)	Change of predicted livestock loss (000 Heads)
		A	B	C=A x B	D	E=B x D	E-C
Temp	(C^0)	-5.73	-4.77	27.35	-4.58	21.88	-5.47
Pre	(mm)	14.69	1.49	21.91	-	21.91	-
Days	(days)	2.59	23.34	60.46	-	60.46	-
Hay	(tonnes)	71,746.15	-0.0012	-82.62	82,508.07	-95.02	-12.39
Dzud	(0 or 1)	0.32	159.14	50.92	-	50.92	-
Loss	(000 Heads)	73.91		78.028		60.165	-17.864

*Mean of variables from Table 4;**Regression coefficients from Table 5

Under assumption 4: 20% increase in ***temp, 15% increase in hay harvest; others remain the same

Assumption 1.*As a result of improved winter camps, the average temperature inside the camps increases by 20%, and herders prepare at least 15% more hay for winter, supported by the DPG programme.*

Grants would be spent on building new winter camps or improving the old winter camps for the livestock; therefore, the temperature inside the camp can be 20% warmer than the average temperature of the study months.

Since the DPG programme document did not report the percentage change of these two of assumption 1 is ***ad hoc***assumption. Using the estimates of ***temp*** and ***hay*** in model, the figure for avoidable livestock loss is calculated.

The total livestock loss is predicted to be 78,028 in one month in 3 provinces. If Assumption 4 is true then this number reduces by 17,864 to 60,165 livestock. If the average temperature in the winter camps increases by 20% then the average would be $-4.58\ C^0$. A 15% increase in the hay harvest gives 82,508 tonnes of hay estimated to be harvested in 3 provinces.

Predicted livestock loss in one year (one year accounts for 6 months) is 468,170 heads of livestock and under assumption 1 this number would be reduced to 360,988 due to benefit of DPGP. It means the avoidable livestock loss is 107.182 per year. In other words, the livestock loss can be reduced by 22.9% ((107.182/468.170)*100%) when the temperature of winter camps increases and the hay harvest increases.In order to calculate the benefit of improved winter preparation of 4500 herder families, it is assumed that one herder household has on

average 375 livestock[2]. Therefore, it is calculated that 4500 families have 1,687,500 livestock that are affected by the DPG programme, which is 21% of total livestock in 3 provinces. Therefore, using this proportion with a total avoidable figure of 107,182 the total estimated figure of prevention of livestock loss, resulting from the programme outcomes of improving winter camps and the hay harvest, is 22,508 in one year. Number of loss-avoidable livestock numbers by each type is calculated by average alive livestock price of 2009.

Table 3

Total avoidable cost of livestock loss

Indicators	Livestock types					Total
	Camel	Horse	Cattle	Sheep	Goat	
Predicted avoidable livestock loss (heads)*	141	1,135	1,328	9,854	10,047	22,508
Average price of livestock in 3 provinces in 2009(USD)**	192.78	118.17	161.84	25.22	17.24	-
Avoidable cost of livestock loss for 4500 HHper year (000 USD)	27.31	134.2	215.08	248.5	173.18	798.275

*The share of livestock types in 2009 in Mongolia is used to find the avoidable livestock loss by types
**Average prices are calculated by author using NSO (2009); 1 USD=1440.76 MNT in 2009.

The result suggest that increasing the temperature of the winter camps by 20% and the hay harvest by 15% (Assumption 4) results in reducing livestock loss by 798,275 USD.

2. Indirect benefit: Avoidable indirect impacts by implementing DPGP

We used unpublished damage data of Dzud 2009-2010 of National Emergency Management Agency (NEMA) (Email from Baigalmaa, P., September 14, 2010) to estimated damages occurred in 3 provinces except death of 1 child and 2 adults. There were 142 people affected and 5 *Gers* blown away by strong wind in 3 provinces[3].

In general, three kinds of damages occurred during Dzud 2009-2010 that could be reduced by the Disaster Prevention Grants Programme, the monetary values of which are presented below.

1. Mongolian Value of Statistical Life: No study has been conducted for the Value of Statistical Life (VSL) of a Mongolian.Thus comparison of GDP per capita between Mongolia and Australia is used with the converter of Australian VSL to Mongolian VSL. Abelson (2008, p. 19) argued that an appropriate estimate for an Australian is 3.5 million USD[27, 28]. According to the International Monetary Fund data of GDP per capita, Mongolian GDP per capita was equal to 8.96% of Australian GDP in 2009[29][4]. Using this proportion, a Mongolian's VSL would be in the region of **313,600 USD** (3.5 million USD * 8.96%), based on Abelson's estimate.
2. Number of people affected: People get affected by Dzud. The value of people's time while stuck on snow-blocked roads for example or getting lost in the countryside, not to mention danger to life and health risks, can be estimated in monetary terms by using the amount of the loss of an average salary for each day. No research has been conducted to suggest how many days are lost due to the Dzud. The national average wage per month in 2009 was 208.57 USD as reported by NSO (2009), and therefore the salary for one day would be 6.95 USD per employee. The calculation below works on the assumption that an affected person loses 6.95 USD per incident caused by the Dzud 2009-2010.
3. Damaged or blown away *Gers* in strong snowstorms: An individual retailer Nyamdorj (2010) exports the *Gers* with price of 1238 USD per *Ger*[30]. This price can be used as value of broken or blown away *Gers* in strong snowstorms during Dzud 2009-2010.

[2] The programme selects a household that has livestock ranging from 250 to 500 heads. We take an average of 375 livestock.

[3] The number of occasions due to Dzud 2010 is taken from NEMA unpublished data between October 2009 and March 2010, based on the damage which occurred inwhole Mongolia. Damages reported were not separately available for each province, thus we assumed that cost of damage is reduced by share of the 3 provinces in the total number of provinces affected.

[4] The International Monetary Fund reports that the Australian GDP per capita is 38,838.902 (PPP) current international dollars and the Mongolian GDP per capita is 3,481.052 (PPP) current international dollars as at 2009[29]. The percentage proportion of Mongolian GDP per capita in Australian GDP per capita is 8.96% ((3,481.052/38838.902)*100%).

Costs can now be estimated using the quantity of damages during Dzud 2009-2010 in 3 provinces and estimated prices. The calculation of costs is presented in Table 4.

Table 4

Total cost of avoidable indirect damages estimated by DPG of the Dzud 2009-2010

	Mortality	Affected People	Broken or Blown away *Gers*	Total
Damage quantity	3	142	5	-
Value/Price per damage (USD)	313,600	6.95	1,238	-
Total damage cost of Dzud 2009-2010 in 3 provinces (USD)	940,800	985.36	6,190	947,975.4

In total, the avoidable indirect impact of the Dzud 2009-2010 in 3 provinces is 947,975 USD for reducing indirect impacts through DPGP. However, the DPGP focused on 4,500 households in 3 provinces, which is 6.8% of the total number of households. In terms of this proportion, DGPP would calculate that 64,462 USD (947,975.4 USD*6.8%) for 4,500 households in 3 provinces would be needed to avoid the damage from the next Dzud.

We assume that reduction level of avoidable direct impacts is the same as avoidable indirect impacts caused by the Dzud.DPGP reduces the direct damage of livestock loss by 22.9%; the same percentage reduction is assumed to occur from indirect effects due to the link between indirect effects and livestock loss.

Therefore, the benefit of DPG for avoidable indirect damages becomes 14,762 USD (22.9% of 64,462 USD). In summary, the total benefit of the Disaster Prevention Grants programme is the sum of the benefits of reduction in direct and indirect damages caused by the Dzud, which is 813,037 USD (798,275 USD+14,762 USD).

3. Choice of the social discount rate in Mongolia

The future value of the benefits should be depreciated to their current value in order to compare costs. Valentim and Prado (2008) researched 167 countries' Social Discount Rates (SDR) and their calculation estimates that Mongolian SDR was 10.8% in 2006[31]. This SDR will be used for the calculation of the net benefit of the DPGP in the following section, because a pure time preference method was used in their calculation and there is no other close estimations currently.

4. Net benefit of the programme

The benefit of the DPGP is 813,037 USD per year which is equivalent to the cost of avoidable damage of Dzud. We assume that the benefit duration of DPGP in future is 7 years and this timescale been used in total social benefit function.The economic growth of Mongolia (g) serves as a factor of increase in damage of subsequent Dzuds in equation 3, although the GDP growth of Mongolia from 2008 to 2009 is 0.6% [32][5].

Table 4

Total benefit of DPGP in present values

Years	Total Benefit (USD)
1	518,025
2	495,583
3	474,114
4	453,575
5	433,925
6	415,127
7	397,143
Total	3,187,493

The probability of Dzud in Mongolia (p) is 66.6% as Purev. B (2000) calculated [33].

The result of the total benefit calculated, using Eq 2, in present values of future benefits given is calculated in Table 4.The total benefit of DPGP in 7 years in present values is **3.19 million USD**. On the other hand, DPGP cost is**2.75 million USD**.The net benefit of the DPGP is the difference between the present value of the total benefits and cost, which is **437,493 USD**. This means that the net benefit of the DPGP is positive, and it is beneficial for the 3 provinces to avoid the future damages of Dzuds in the next 7 years.

CONCLUSIONS

[5] GDP calculated at current values in 2008 was 6019838; and 6055794,29, in 2009, hence the GDP growth from 2008 to 2009 in Mongolia is 0.6% [32].

1. Disaster Prevention Grants Programmeis beneficial to the rural herders who were affected by the Dzud 2009-2010 during the next seven years as net benefit is strong enough. Because the total benefit of the programme is higher than its cost.
2. Direct benefit of DPGP is livestock loss reduction when the winter preparation improved; for example, improving winter camps and harvesting more hay which was valued as 798,275 USD. As a result of the time series model of Livestock Loss, the DPG programme may reduce avoidable livestock loss by 22.9% in the 3 provinces.
3. The model of livestock loss reveals that temperature, amount of hay production and number of days with strong wind during the winter and spring time are the significant factors that affect to the livestock loss. The households should prepare the warm shelters, and increase the hay harvest before winter time to reduce the livestock loss during Dzud time.
4. The UNDP should continue the Disaster Prevention Grants Programme as this programme has positive net benefit to the society of three provinces.

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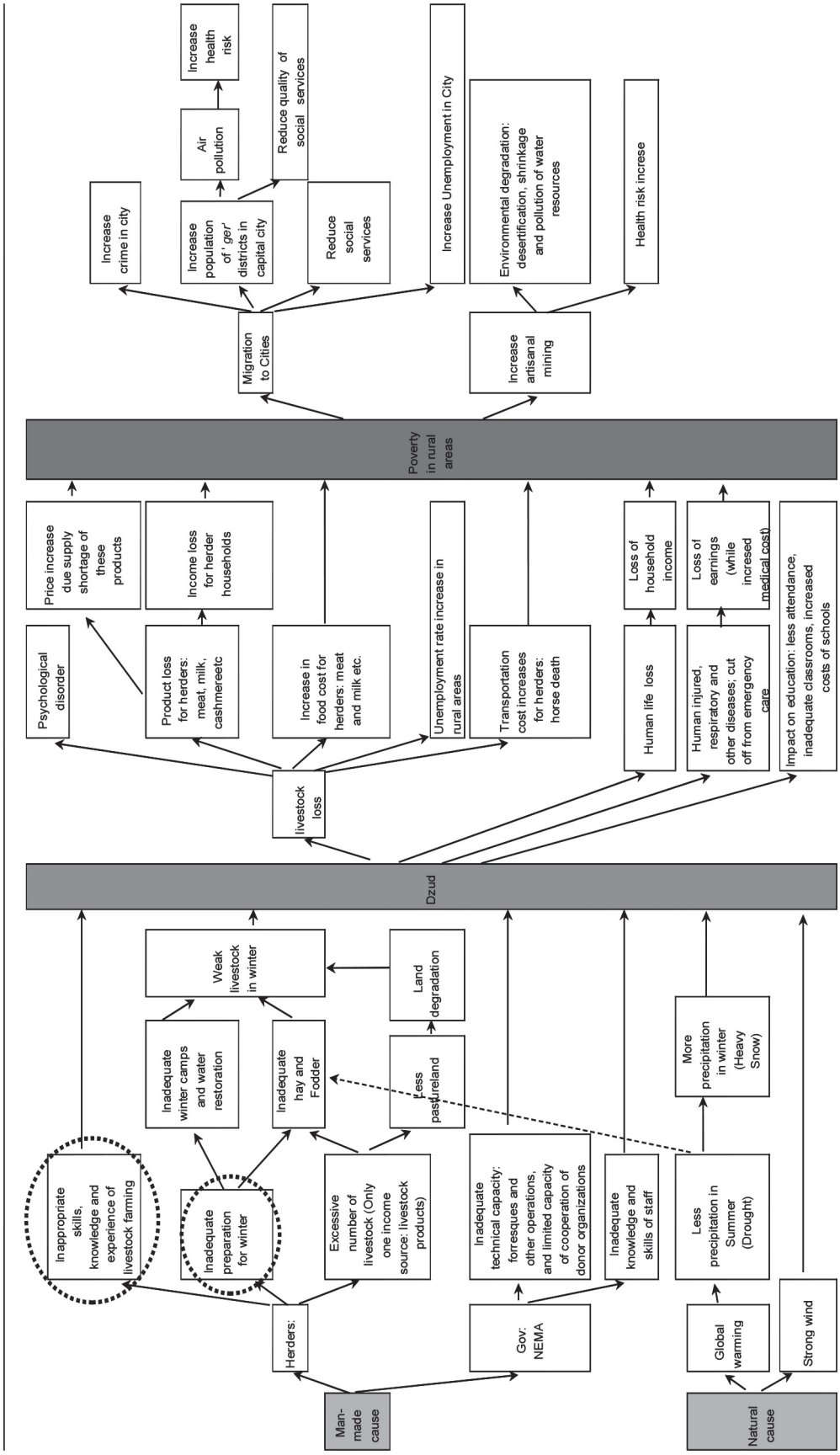
Appendix: Schema of Cause and Effect Chain of Dzud



Note: the ER programme cuts off the causal chain of Dzud impacts from beginning stage: i.e Man-made cause of Dzud damages almost prevented by ER programme (See Chapter 4)

Disaster Prevention Grants Programme

Source: Author's diagram [1]