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Damage and Loss Assessment in Agriculture Sector Caused by Hazards (Georgian Case Study)

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Natural and man-made hazards may disrupt and affect negatively agricultural sector. 0Damage and loss caused by disasters which are likely to become more frequent and severe due to Climate Change effects, need to be assessed, because precise sector-specific disaster losses and damage data are a vital indication for disaster risk reduction and policy-making. This paper responds to the necessity of creation a unified methodology for the damage and loss assessment in Agriculture Sector in Georgia. The paper introduces a comprehensive formula for damage assessment in agriculture sector. Assessment formulas has been designed to be compliant to the Sendai Framework requirements while enforcing the assessment of damages in agriculture with a multi-temporal dimension. The proposed methodology differs from other well know methodologies (ECLAC- DaLA, FAO and UNSDR methodologies) by excluding certain aspects and adding relevant variables (e.g. yield per hectare by region, irrigation and varieties; production capacity until full recovery of perennial crops etc. has been considered). Collected data can be used to calculate volume of compensation in agriculture sector and improve compensation procedures. As well as, it will enable relevant government agencies, private insurance companies, and research institutes to develop (calibrate) damage and loss assessment models.

Keywords *Disaster Assessment, Damage and Loss, Agriculture Sector, Georgia*

JEL Codes: *Q10, Q18, Q58*

Introduction

In order to effectively address the damage and loss, problems and challenges caused by natural and man-made hazards, the Government of Georgia has developed a Disaster Risk Reduction (DRR) Strategy and Action Plan (Order of Government of Georgia, 2017). The most important part of the disaster risk

reduction strategy and action plan is to develop a unified system for assessing the damage and loss caused by natural and man-made hazards.

Procedures and regulations in Georgia that ensure the creation of database for damage and loss caused by a natural and man-made hazard, its openness and the collection of additional information from relevant stakeholders need to be significantly improved at both central and municipal level. There is no unified system of disaster damage and loss assessment, which could be managed, regularly updated and then used for disaster risk management by the relevant authorized government agencies. Therefore, neither private organizations (especially research institutes and insurance companies) have the opportunity to conduct research activities to prevent natural and man-made hazards, improve risk management and promote the development of the insurance market related to damage and loss caused by natural and man-made hazards.

According to the common practice in Georgia, the damage and loss caused by natural and man-made hazards are assessed and registered by a commission established at the local level (Order of the Governor of Lagodekhi Municipality, 2016). Due to the fact that there is no systematic/standardized approach to how the commission should assess the damage caused by a hazard, each assessment act and the amount of damage and loss calculated are based on the subjective opinions, visions and assessments of the commission members.

The aim of the research is to create a unified methodology for the damage and loss assessment in agriculture sector caused by natural and man-made hazards, which will help to provide full and comparable reporting of the required information on the loss, increases the reliability of the data and lessen a subjective factor during assessment.

Theoretical and practical findings of the research can be used by the legislative and executive bodies of Georgian, an insurance companies and practitioners to address current issues in the field.

Development of a standardized methodology for assessing the damage and loss in agriculture sector caused by natural and man-made hazards will improve the management of issues such as: accounting-standardization, comparability with international databases, the ability to exchange information and accuracy. Also, will assist to fulfill the obligations under the EU-Georgia Association Agreement and SENDAI (UN, 2015).

Systematic collection of disaster damage and loss data in agriculture sector, in addition to the issues listed above, will enable relevant government agencies, private insurance companies, and research institutes to develop (calibrate) damage and loss assessment models. The last one can be used to assess the short-term and long-term economic shocks and social environment lead by natural and man-made hazards. Also, collected data can be used to calculate

compensation for the victims of the disaster. Therefore, defined compensation in turn will help establish a fair and effective state aid mechanism, facilitate cooperation with the local community, the private sector and the international community and will enable insurance market development.

The existing literature on the assessment of damage and loss caused by natural and man-made hazards, which deals with post-event assessments[1], can be divided into three groups. First, Studies that assess specific types of impacts. In particular, short-term and long-term, direct and indirect, and economic impact on a particular sector. Second, which include damage assessment as a result of a specific natural event/catastrophe (e.g. earthquake (Erdik M. K., etc., 2011); drought (Nagarajan Ramanathan, 2010; Y. Ding, M.J. Hayes, M. Widhalm, 2011; Cui, Y., etc., 2019); flood (Jonkman B., etc., 2008;

Dutta D., Srikantha H., Musiake K. A., 2003; WMO etc., 2013; Ruiz V., 2017 etc.). Third, comprehensive multisectoral methodologies for assessing damage and loss caused by natural and man-made hazards (APEC Workshop, 2009; Moore, W. R., and Willard P., 2014).

According to D. Eckhardt, A. Leiras და A. Marcio TT (2019) there are 12 methodologies for assessing the damage caused by a natural disaster/ catastrophe and 11 general frameworks. One of them are:

1.Handbook for Estimating the Socio-economic and Environmental Effects of Disasters worked out by United Nation's (UN) Economic Commission for Latin America and the Caribbean (ECLAC- DaLA). This methodology (guide) is one of the most widely used in the world (many other methodologies and guidelines are using the approach and calculation formulas). However, each state significantly adapts presented methodology based on their needs.

2. Methodology for damage and loss assessment in agriculture (Conforti, P., etc., 2020), worked out by Food and Agriculture Organization of the UN assesses following type of damages:

- Direct damage and loss to crops;
- Direct damage and loss to livestock;
- Direct damage and loss to forestry;
- Direct damage and loss to aquaculture;
- Direct damage and loss to fisheries.

We are considering evaluation approaches worked out by FAO. However, due to the specifics of Georgia and the existing needs, important details have been added to the calculation formulas presented in the methodology and some adjustments have been made. For example, we are considering in which period

1 There are pre-event assessment frameworks and guidelines.

of season the natural event/disaster is occurring. It is also foreseen that in case of complete destruction of the sown area, the farmer will no longer have to bear the planned costs, etc.

During elaboration of formulas for assessing agriculture damage and loss caused by natural and man-made hazards, we have consulted with representatives from the Ministry of Environment Protection and Agriculture of Georgia and it's Scientific-Research Center of Agriculture. Thus, the required data is divided into two parts: data (provided form certain departments of the Ministry and Scientific-Research Center[1]) that might be integrated in advance in a specially developed software and the data that will be collected from the field work.

Damage and Loss Assessment

When we assess damage and loss caused by hazards in agriculture sector, we should consider particular characteristics associated with it, such as seasonality. Therefore, damage and loss incurred in the sector will depend on when the disaster occurred in the season. Also, we should consider the country specifics and whether there was destruction on trees and plants or not. So, basically, we should consider all relevant scenarios during working out damage and loss assessment methodology in agriculture sector in Georgia.

Damage to agriculture as a result of natural and man-made hazards can be divided into direct and indirect losses. Direct loss contains losses caused by damage/destruction of the crops and planting areas, physical infrastructure and machinery. As well as losses caused by damage or destruction of the crops and their supplies. Indirect losses include all losses incurred as a result of reduced production caused by direct losses (ECLAC., 2003).

The damage and loss assessment methodology for agriculture sector in Georgia discusses all the scenarios that are important to consider in the assessment process. In particular, in the case of perennials:

- Is there any damage during the harvest period, without directly damaging the plants;
- or whether there is damage in the period before the fruit ripens, without directly damaging the plants;
- or whether perennials are directly damaged, without loss of yield.
- And in the case of annual crops:
- Depending on the season, is it possible to re-sow the plants;
- Whether there is an impact on livestock.

Proposed formulas to assess damage and loss in agriculture sector caused

1 If there is no data, as we have explained, Scientific-Research Center can provide them after conducting the research based on specific needs;

by natural and man-made hazards assess the damage and loss incurred as a result of damage to perennial, annual crops and livestock.

What about natural disasters or man-made hazards that damage fisheries (sea fishing), forestry and aquaculture, we can use the formulas developed by FAO (Conforti, P., etc., 2020) or the UN Disaster Risk Reduction Service based on the FAO methodology (UNISDR., 2018.). However, in our opinion, the assessment of damage and loss to fisheries (sea fishing) and forestry is more significantly related to the damage caused to the environment as a result of a natural disaster, and is presented in the Environmental Impact Assessment Methodology developed by the Georgian Government. Moreover, the damage and losses to aquaculture should be assessed by the entrepreneur.

It is also important to note that the damage and loss to agriculture related buildings are calculated using the methodology for assessing the damage to non-residential buildings (Modebadze G., 2021). Also, assessment of the damage caused by interruption of agriculture related entrepreneurial activities (farms, means for cultivation and caring for agricultural products, storage facilities and warehouses) should be conducted by entrepreneur.

To assess damage and loss in agriculture sector we should consider all relevant scenarios for perennial and annual crops, as well as for livestock.

Perennial Crops

1. Without damaging trees and plants

Damage and loss to agriculture caused by natural and man-made hazards for perennial crops without damaging trees can be calculated by the following formula:

$$D_1 = S * A_n * q * p * \left(\frac{A_n - A_s}{A_n}\right)$$

Where,

S - Damaged area (ha).

A_n - Expected yields per plant by age and region[1] (kg). Where, *n* is between *1* and *T*.

A_s - Actual yields per plant at non-fully damaged harvested area (kg).

q – Actual number of plants per ha.

p - Farm gate price per kg.

$\left(\frac{A_n - A_s}{A_n}\right)$ - The degree of damage to the crop, where A_s - Actual yields per plant (kg).

1 The data can be provided from Scientific-Research Center of Agriculture in Georgia.

The variables given in the formula for calculating the damage and loss caused by natural and man-made hazards are divided into the following categories:

Pre-defined / integrated data:

T - Number of years required for the plant to be fully mature[1].

A_n - Expected yields per plant by age and region (kg). Where, *n* is between *1* and *T*.

p - Farm gate price per kg.

Q - Optimal number of plants per ha.

The data that will be determined on the spot during the evaluation process:

S - Damaged area (ha).

n – Actual age of the plant.

q - Actual number of plants per ha. If q>Q then q=Q.

A_s - Actual yields per plant (kg).

It is important to note that even if the damage occurs in the period before the crop ripens without damaging the tree, the plant still needs proper care throughout the year so that plant still be productive for next year. Consequently, the cost of caring a perennial crop by age per plant, in this case, was not excluded. Also, we should note that the damage and loss incurred during the harvest period or before its ripening without damaging the tree are equal.

2. Damage to perennials without loss of current yield

The FAO Damage and Loss assessment methodology is based on number of assumptions. One of them states that "for perennial crop losses, fully damaged hectares are replanted the same year of the disaster and no production is available until full recovery" (Conforti, P., etc., 2020), which is not the case for Georgia, because, before full recovery perennial crop can give fruit (few but still can). Therefore, damage and loss to perennial crops caused by natural and man-made hazards when perennial crops have been damaged without loss of current crop can be calculated by the following formula:

$$D_2 = \left[\frac{q - q_s}{q} * \left(\left(I + \sum_{1}^{n} C_n + \sum_{n}^{2n} \frac{A_n * p * q}{(1+r)^t}\right) - \sum_{n}^{2n} C_n\right)\right] * S$$

Where,

S - Damaged area (ha).

I – replacement value of fully damaged tree (initial investment).

C_n - The cost of caring a perennial crop per plant based on age of the tree.

1 The data can be provided from Scientific-Research Center of Agriculture in Georgia.

T - Number of years required for the plant to be fully mature[1].

n - Actual age of the plant. if *n>T, then n=T*.

p - Farm gate price per kg.

A_n - Expected yields per plant by age and region (kg). Where, *n* is between *1* and *T*.

q - Actual number of plants per ha. if q>Q, then q=Q.

Q - Optimal number of plants per ha.

– Number of non-damaged plant per ha.

r – discount rate (future value (FV)).

t - year t=1....n.

The variables given in the formula for calculating the damage and loss caused by natural and man-made hazards are divided into the following categories:

Pre-defined / integrated data:

I – replacement value of fully damaged tree (initial investment).

C_n - The cost of caring a perennial crop per plant based on age of the tree.

T - Number of years required for the plant to be fully mature[2].

p - Farm gate price per kg.

A_n - Expected yields per plant by age and region (kg). Where, n is between 1 and T.

Q - Optimal number of plants per ha.

r – discount rate (future value (FV)).

The data that will be determined on the spot during the evaluation process:

S - Damaged area (ha).

n - Actual age of the plant. if n>T, then n=T.

q - Actual number of plants per ha. if q>Q, then q=Q.

q_S – Number of non-damaged plant per ha.

II. Annual Crops

1. If the event occurred at the end of the season

The formula proposed by the FAO, which calculates the damage to annual crops caused by natural and man-made hazards, takes into account the cost of recovering the damaged area in the short term. We are not considering such expenses in our calculation, because it is very subjective and depends on farmers judgment and assessment will be biased. Farther more, instead of dividing partially damaged and completely destroyed sown areas, the degree of damage was introduced, which provides more flexibility in the assessment process. Also,

1 The data can be provided from Scientific-Research Center of Agriculture in Georgia.

2 The data can be provided from Scientific-Research Center of Agriculture in Georgia.

in order to ensure maximum accuracy of the assessment, it is important to calculate the potential yield per hectare by region, irrigation and varieties[1]. Therefore, the damage caused by damaged to annual crops at the end of the season can be calculated using the following formula:

$$D_3 = S * A_P * P * \frac{A_P - A_s}{A_P}$$

Where,

S - Damaged area (ha).

A_p - Expected yields per ha by region, irrigation and varieties (kg).

A_s – Non damaged crop per ha.

P - Farm gate price per kg.

$\frac{A_P - A_S}{A_P}$ - the degree of damage to the crop.

The variables given in the formula for calculating the damage and loss caused by natural and man-made hazards are divided into the following categories:

Pre-defined / integrated data:

A_p - Expected yields per ha by region, irrigation and varieties (kg).

P - Farm gate price per kg.

The data that will be determined on the spot during the evaluation process:

S - Damaged *area (ha).*

A_s – Non damaged crop per ha.

2. Replant is possible after disaster

In this case, the loss is determined by the amount of investment made before the event.

$$D_4 = S * I_m * \frac{S - S_1}{S}$$

Where,

S - Damaged area (ha).

A_1 – Area of survived crops on damaged area which do not require replanting (ha).

I_m - Costs of growing annual crops according to the agro-production calendar by regions[2].

1 The data can be provided from Scientific-Research Center of Agriculture in Georgia.

2 The data can be provided from Scientific-Research Center of Agriculture in Georgia.

m - The period according to the agro-production calendar when a natural disaster occurred.

The variables given in the formula for calculating the damage and loss caused by natural and man-made hazards are divided into the following categories:

Pre-defined / integrated data:

I_m - Costs of growing annual crops according to the agro-production calendar by regions

The data that will be determined on the spot during the evaluation process:

S - Damaged area (ha).

S_1 – Area of survived crops on damaged area which do not require replanting (ha).

m - The period according to the agro-production calendar when a natural disaster occurred.

3. Replanting is not possible after the event

$$D_5 = D_3 - I_m * \frac{S - S_1}{S}$$

Where,

D_3 - Damage if the event occurred at the end of the season.

S - Damaged area (ha).

I_m - Costs of growing annual crops according to the agro-production calendar by regions[1] (From the beginning of occurred event to the end of the harvest).

S_1 - Area of survived crops on damaged area which do not require replanting (ha).

m - The period according to the agro-production calendar when a natural disaster occurred.

The variables given in the formula for calculating the damage and loss caused by natural and man-made hazards are divided into the following categories:

Pre-defined / integrated data:

I_m - Costs of growing annual crops according to the agro-production calendar by regions

The data that will be determined on the spot during the evaluation process:

m - The period according to the agro-production calendar when a natural disaster occurred.

S - Damaged area (ha).

1 The data can be provided from Scientific-Research Center of Agriculture in Georgia.

III. Livestock's

Damage caused by the death and/or loss of animals and poultries only if animals are used for meat production can be calculated by the given formula below. It is important to note that we have limited ourselves to meat production only as it is a major part of the benefits derived from animals and poultry.

Due to the fact that assessing damage and loss of other products (hides, skins, eggs and other) obtained from animals and poultries (except in the case of farm production) are associated with a number of difficulties, we decided not to consider this component in the formula, unlike FAO methodology.

$$D_6 = Q_i * W_{i_t} * k_i * P_i$$

Where,

Q_i – Number of dead or loss livestock's.

W_{it} - Average weight of animal and poultry by age and varieties.

k_t - Meat yield coefficient by age and varieties[1]

P_t - Farm gate price per kg meat.

t – age of dead or loss animal

The variables given in the formula for calculating the damage and loss caused by natural and man-made hazards are divided into the following categories:

Pre-defined / integrated data:

W_{it} - Average weight of animal and poultry by age and varieties.

k_t - Meat yield coefficient by age and varieties[2]

P_t - Farm gate price per kg meat.

The data that will be determined on the spot during the evaluation process:

Q_i – Number of dead or loss livestock's.

t – age of dead or loss animal

Conclusion

Proposed methodology corresponds to standardize disaster impact assessment in agriculture, it considers Georgia's specifics and relevant stakeholders needs. Also, it can be applied in different disaster events and in different regions in Georgia. The assessment methodology is precise enough to consider all agricultural subsectors and their specificities. In addition, the methodology can be used to identify, analyze and evaluate the impact of natural and man-made hazards on the agriculture sector, and creates a useful tool for gathering and

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2 The data can be provided from Scientific-Research Center of Agriculture in Georgia.

interpreting existing information to inform risk-related policy decision-making and planning.

Proposed methodology differs from other well know methodologies (ECLAC-DaLA, FAO and UNSDR methodologies) by excluding certain aspects and adding relevant variables:

- Instead of dividing partially damaged and completely destroyed sown areas, the degree of damage was introduced in proposed assessment methodology, which provides more flexibility in the assessment process;
- In order to ensure maximum accuracy of the assessment, potential yield per hectare by region, irrigation and varieties are used in the proposed calculations;
- The proposed assessment methodology considers production capacity until full recovery of perennial crops;
- The proposed methodology for Georgia does not consider the cost of recovering the damaged area in the short term, because it is very subjective and depends on farmers judgment.

Developed standardized methodology for assessing the damage and loss in agriculture sector caused by natural and man-made hazards will improve the management of issues such as: accounting-standardization, comparability with international databases, the ability to exchange information and accuracy. Also, will assist to fulfill the obligations under the EU-Georgia Association Agreement and SENDAI.

Systematic collection of disaster damage and loss data in agriculture sector, in addition to the issues listed above, will enable relevant government agencies, private insurance companies, and research institutes to develop (calibrate) damage and loss assessment models. The last one can be used to assess the short-term and long-term economic shocks and social environment lead by natural and man-made hazards. Also, collected data can be used to calculate compensation for the victims of the disaster. Therefore, defined compensation in turn will help establish a fair and effective state aid mechanism, facilitate cooperation with the local community, the private sector and the international community and will enable insurance market development.

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სოფლის მეურნეობისათვის სტიქიური უბედურებით მიყენებული ზარალის შეფასების მეთოდოლოგია (საქართველოს მაგალითზე)

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ბუნებრივი და ადამიანური ფაქტორებით გამოწვეული კატასტროფების ზარალის, პრობლემების და გამოწვევების ეფექტიანად გადაჭრის მიზნით, საქართველოს მთავრობამ შეიმუშავა კატასტროფის რისკის შემცირების (DRR) სტრატეგია და სამოქმედო გეგმა. კატასტროფის რისკის შემცირების სტრატეგიისა და სამოქმედო გეგმის ყველაზე მნიშვნელოვანი ნაწილია აღნიშნულის შედეგად დამდგარი ზარალის შეფასების ერთიანი სისტემის შემუშავება, კერძოდ, სოფლის მეურნეობისთვის მიყენებული ზარალის დათვლის უნიფიცირებული მეთოდოლოგიის შექმნა, რაც უზრუნველყოფს ზარალის შესახებ საჭირო ინფორმაციის სრულად და შესადარი ფორმით აღრიცხვა-ანგარიშგებას, აამაღლებს ზარალის შესახებ მონაცემების სანდოობას და უზრუნველყოფს შეფასებისას სუბიექტური ფაქტორების მინიმიზაციას.

კვლევის შედეგების თეორიული და პრაქტიკული მიგნებები შესაძლებელია გამოყენებულ იქნეს საქართველოს საკანონმდებლო და აღმასრულებელი ორგანოების, სადაზღვეო კომპანიების და ამ სფეროში დასაქმებული პრაქტიკოსი მუშაკების მიერ მიმდინარე აქტუალური საკითხების გადაწყვეტისას (ზიანისა და დანაკარგის შეფასების მოდელები, სტიქიის შედეგად დაზარალებულთა კომპენსაციის მოცულობის გამოთვლა და სხვა).

D. Eckhardt, A. Leiras და A. Marcio TT-ს მიერ 2019 წლის კვლევის თანახმად, მსოფლიოში არსებობს ბუნებრივი მოვლენის/კატასტროფის შედეგად დამდგარი ზარალის შეფასების 12 მეთოდოლოგია და 11 ზოგადი ჩარჩო მონახაზი (framework). მათ შორის, გაეროს სურსათის და სოფლის მეურნეობის ორგანიზაციის (FAO) მიერ ამ

მეთოდოლოგიაში წარმოდგენილ გამოთვლით ფორმულებს დაემატა მნიშვნელოვანი დეტალები და გარკვეული კორექტივები იქნა შეტანილი. მაგალითად, მხედველობაში იქნა მიღებული - ბუნებრივი მოვლენა/კატასტროფა სეზონის ან პერიოდში ხდება. ასევე გათვალისწინებულია, რომ ნათესი ფართობის სრულად განადგურების შემთხვევაში ფერმერს აღარ მოუწევს დაგეგმილი ხარჯების გაღება. ასევე მიყენებული ზიანის და დანაკარგის შეფასების ფორმულებით დგინდება მარცვლიანი და ერთწლიანი კულტურების დაზიანების შედეგად დამდგარი ზარალი და მეცხოველეობისთვის მიყენებული ზიანი და დანაკარგი.

ისაც შეეხება სოფლის მეურნეობის შენობა-ნაგებობებისთვის მიყენებულ დანაკარგებს, დაანგარიშდება არასაცხოვრისი შენობა-ნაგებობებისთვის მიყენებული ზარალის შეფასების მეთოდოლოგიით, ხოლო სოფლის მეურნეობასთან დაკავშირებული სამეწარმეო საქმიანობისთვის (ფერმები, სასოფლო-სამეურნეო პროდუქციის მოყვანის და მოვლის საშუალებების და მოსავლის შემნახველი საცავები) მიყენებული ზარალის შეფასება ეკისრება აღნიშნული საქმიანობების მწარმოებელს.

საკვანძო სიტყვები: *კატასტროფის შეფასება, ზიანი და ზარალი, სოფლის მეურნეობის სექტორი, საქართველო.*

JEL Codes: *Q10, Q18, Q58.*