Conference Paper

Forest Fires in Greece and Their Economic Impacts on Agriculture

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Abstract

Forest fires have increased in the last decades, due to many factors such as climate change, land use change and management. In Greece, wildfires burn cultivated lands and affect significantly the rural economy and society. However, the economic impacts of forest fires on agricultural areas has not been estimated, and this is our aim. After an extended literature review and consultation with the stakeholders, we decided to build a model with many variables. The total cost of fire depends on the cost of prevention and suppression measures, and also direct and indirect costs. Direct costs, as adjusted for the immediate effects of fire, are divided into two categories: direct damages instantaneous and direct losses induced. Direct damages are estimated by a function that calculates the instantaneous damage in permanent crops, seasonal crops, livestock, infrastructure, construction and machinery. Direct losses are estimated by a function that calculates fire-induced costs in permanent crops, seasonal crops, livestock, additional borrowing costs and services costs. For the composition of the time-space model, we will use secondary data, as well as data originated from fieldwork. The literature review showed that the ex post analysis involving detailed consultation with a representative sample of affected farms, provides a more consistent appraisal.

Keywords: Forest fires, cost, agriculture, economic impacts

jel CLASSIFICATION codes: C54, Q24, Q50

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1. Introduction

An increase in the number of wildfires and burned area has been reported during the last decades in many parts of the world [1-5]. Wildfire is one of the most important disturbances in the Mediterranean area causing human losses and damages to tangible assets, environmental services and landscape goods [6-9]. There are no estimates of the suppression expenditures or the economic impact of the fires in the Mediterranean basin region [10].

The agricultural sector is particularly vulnerable to natural hazards and disasters [11]. The desertification of rural areas and the abandonment of agricultural land is related to the recent increase in forest fires in Greece [12], but also across southern Europe [13]. Disasters can be detrimental to crop growth, livestock, health, fisheries and aquaculture production and can seriously undermine the forestry sector [11]. Agricultural losses strongly depend on the crops affected [14]. In Greece, most fires usually occur during the dry season, from June to October. For this reason, crops such as wheat, barley or oats, harvested earlier in the summer, are not usually affected by forest fires. However, significant damage can be caused to permanent crops, such as tree-orchards, olive trees, or vines, with significant implications for the local rural economy. Seasonality is an essential parameter to take into consideration to define damage to crops and damage to perennial plant material [15].

The extend of arable burned land in relation to burned forests and forestland in Greece, in Figure 1, highlights the important role of burned arable land, for the management and economic impacts of forest fires. Economic impacts of forest fires in various sectors, have been studied thoroughly by many researchers, but there are very little about agricultural areas and this study aims to fill this gap. Estimating the impact of a disaster on agriculture is a multifactorial and complex task [16]. In this paper we will identify potential methods that can be used for the economic evaluation of forest fire damages on agricultural areas. The main objective of this paper is, to develop and present a model to assess the economic impacts of wildfires on agricultural areas of Greece. The structure of the manuscript is organized as follows; section 2 describes the Methodology employed, the review of the existing literature, followed by definition and terminology clarification will lead us to the general formula of the Total Cost of Fire in agriculture. Next in subsection 2.1, is presented analytically the estimation of Direct Damages and in 2.2 the estimation of Direct Losses. Concluding, the developed methodology is recapped, presenting the ways to validate the developed model, its utility and further research suggestions.

2. Methodology

The appropriate methodology (Figure 2). has to be selected in accordance to the objective of the study. Messner et al. 2007 argues that it is important to choose a suitable length of time and the geographic extent over which the effects are felt [18]. The model variables were selected after a thorough literature review and the collection

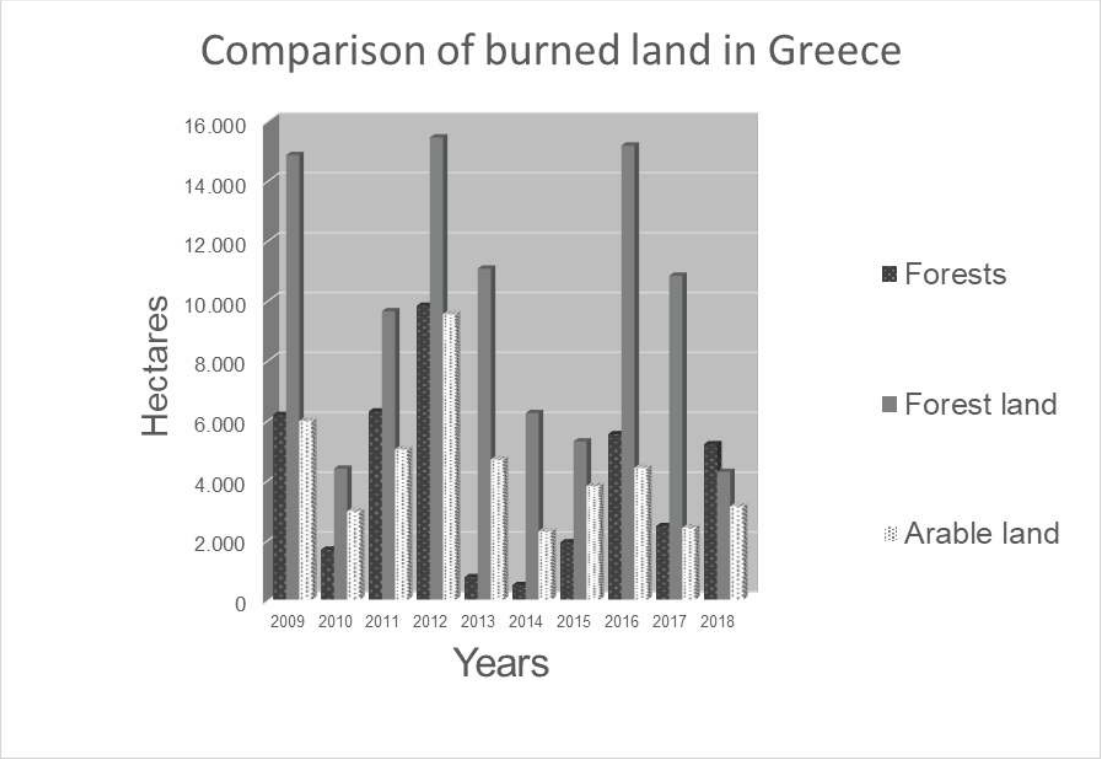

Figure 1: Hectares burned of Arable land, Forests and Forest Land in the past decade [17].

of stakeholders' views. The time and spatial boundaries will depend on the availability of resources and data.

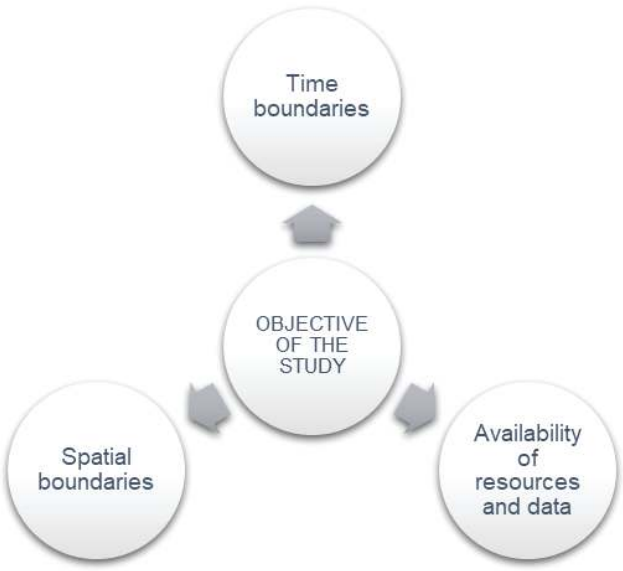

Figure 2: Appropriate methodology (Adjusted Messner et al. 2007 [18]).

The existing literature revealed numerous studies on the economic impacts of forest fires on health [19-21], recreation [22-28], wildlife [7, 29-30], hunting [31-34], residential property [24, 35-36] etc. Taking into account that the economic impacts of disasters on

agriculture in general, resemble those of floods in terms of crop loss, as well as damage to agricultural buildings, contents, machinery, soil erosion and loss of livestock [14, 37-38], the literature search has been extended towards these directions. Floods, droughts and tropical storms affect the agricultural sector [39] and their economic impacts have been studied thoroughly by many researchers. [11,14-15,18,39,40-50]. In the analysis of the 2007 summer floods in Britain [43], the methodology used was an ex post analysis, involving detailed consultation with a representative sample of affected farms which allowed a more systematic audit of damage costs and associated indirect costs. The experience from flood impact studies, in 2007 and 2014 in England, is that it is difficult to anticipate the scale of the economic cost in the immediate aftermath of the flood events [48]. Brémond et al. (2013), concluded that in order to evaluate potential agricultural damage from floods existing ex-ante studies to evaluate damage to agriculture often consider too few damage categories, sometimes only crop damage, although ex-post studies point out that other farm components are also impacted [15]. Another economic assessment of the impacts of the winter 2013/2014 flooding on agriculture, which was commissioned by DEFRA UK, to ADAS UK Ltd, also comes to the conclusion that for a robust analysis of flood damage costs, it would be necessary to undertake an ex post study, involving an audit of a reliable sample of affected farms to secure evidence of impact [51]. The Handbook for Disaster Assessment, by the Economic Commission for Latin America and the Caribbean (ECLAC), estimates the financial costs of a disaster with a view to determining the amount of sector-specific funding needed for recovery and reconstruction efforts (including risk prevention measures) to restore a country or a region to its pre-disaster situation [16]. In estimating damage from forest fires, the handbook, estimates damage to forests, distinguishing native forest lands and planted trees for their lumber. In the latter case forest fire damage is estimated using the same method as for permanent crops [16]. The disaster assessment methodology, as mentioned above, was applied by Glauber & Gunawan (2016), in order to analyze the cost of fire of Indonesia's 2015 fire crisis [52]. Costs are based on an analysis of the types of land burned as reported by the Government of Indonesia. Where available, actual costs are used. Calculated damages are an estimate of the amount of financing needed for reconstruction and rehabilitation, while calculated losses represent the reduction in economic activities and income resulting from the disaster. Damages to agriculture include those to infrastructure and equipment, while losses capture the cost of reclaiming burned lands for planting and the foregone production revenue during this reclaiming period [52].

The use of the terms ``damages'' and ``losses'', in agricultural disasters such as floods, as well as their subdivisions (direct, indirect, tangible, intangible, etc.), are not similarly used in the literature. Interpretations, delineations and terminology relating to damages and cost types sometimes differs in the literature and among hazard communities [40, 47, 53-56]. According to Merz et al (2010), direct damages are those which occur due to the physical contact of flood water with humans, property or any other objects; indirect damages are induced by the direct impacts and occur -- in space or time -- outside the flood event [44]. The ConHaz (Costs of Natural Hazards) project explains the terminology and classifications which are used in the literature to describe the impacts and costs of droughts, and also describes and compares the main methods for assessing all types of drought costs, i.e. direct, indirect and intangible costs [45]. Intangible costs, are difficult to both identify and quantify, due to lack of data availability and insufficient knowledge of full disaster damage [47]. Another distinction by using the word instantaneous and induced damage, to create temporal distinction, is proposed by Brémond et al. (2013) [15]. As it is defined in Hall's (2014) report, the "total cost" of fire includes the losses that fire causes, directly and indirectly, and the cost of provisions to prevent or mitigate the losses caused by fire. Indirect loss could also include dollar equivalents for environmental damage or damage to cultural heritage, but there is no good data source available on these types of indirect damage, and they are not included in this report [57]. In our study in order to proceed with the costs of fire in agriculture, we have categorized the cost of fire combining the above literature and adapting the terminology to fires. We have taken into account that in the case of fires, damage is more direct than flood or drought damage and is equally catastrophic in both permanent and annual crops. This resulted in the Total Cost of fires in agriculture as shown in Figure 3.

The Total Cost consists of prevention and suppression costs, in addition to direct costs and indirect costs. Direct costs include direct damage caused instantly by the fire, and direct losses induced. Indirect costs of fire include costs that are not directly related to the fire: Health costs, social, environmental, aesthetics, or costs to businesses affected by damaged production such as processing (olive mils, wineries, dairies etc.) and agro-tourism, which can be intangible or tangible costs. In our study, the estimation of fire costs in agricultural areas focuses on the cost of direct instantaneous damages and direct induced losses (adjusted from ECLAC, 2014) The general formula for estimating the direct costs is:

Direct Costs = Direct Damages + Direct Losses (DC=DD+DL) Figure 4.

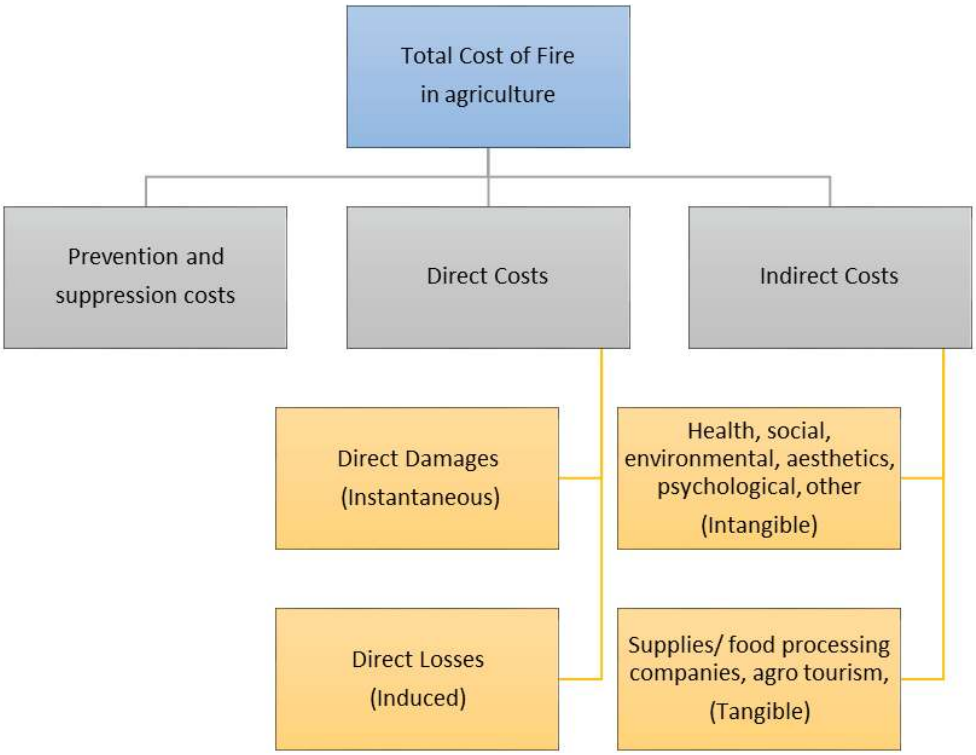

Figure 3: Total Cost of Fire= Cost of prevention and suppression measures + Direct Costs + Indirect Costs.

2.1. Direct damages estimation

Direct Damages are estimated as follows:

DD = Direct Damages (Permanent crops+ Transitory crops+ Livestock+ Fixed Assets+ Other).

2.1.1. Direct damages on permanent crops

Permanent crops are ornamental crops or long cycle crops. [16]. In Greece, such crops are grapes, apples, pears, peaches, citrus fruits and olive trees. Damages may include both crop and production costs depending on the timing of the fire and the seasonality of each crop.

Direct Damages on Permanent crops (DDP) are calculated using the equation below:

DDP = $\sum_i (DPCi + DPPi - DPHi - DPIni)$

Where

i: type of Permanent crop and

DPCi: Damage of Permanent crop Cultivation material=cost of replanting (€)

which is calculated as the number of plants/ trees * unit cost (€)

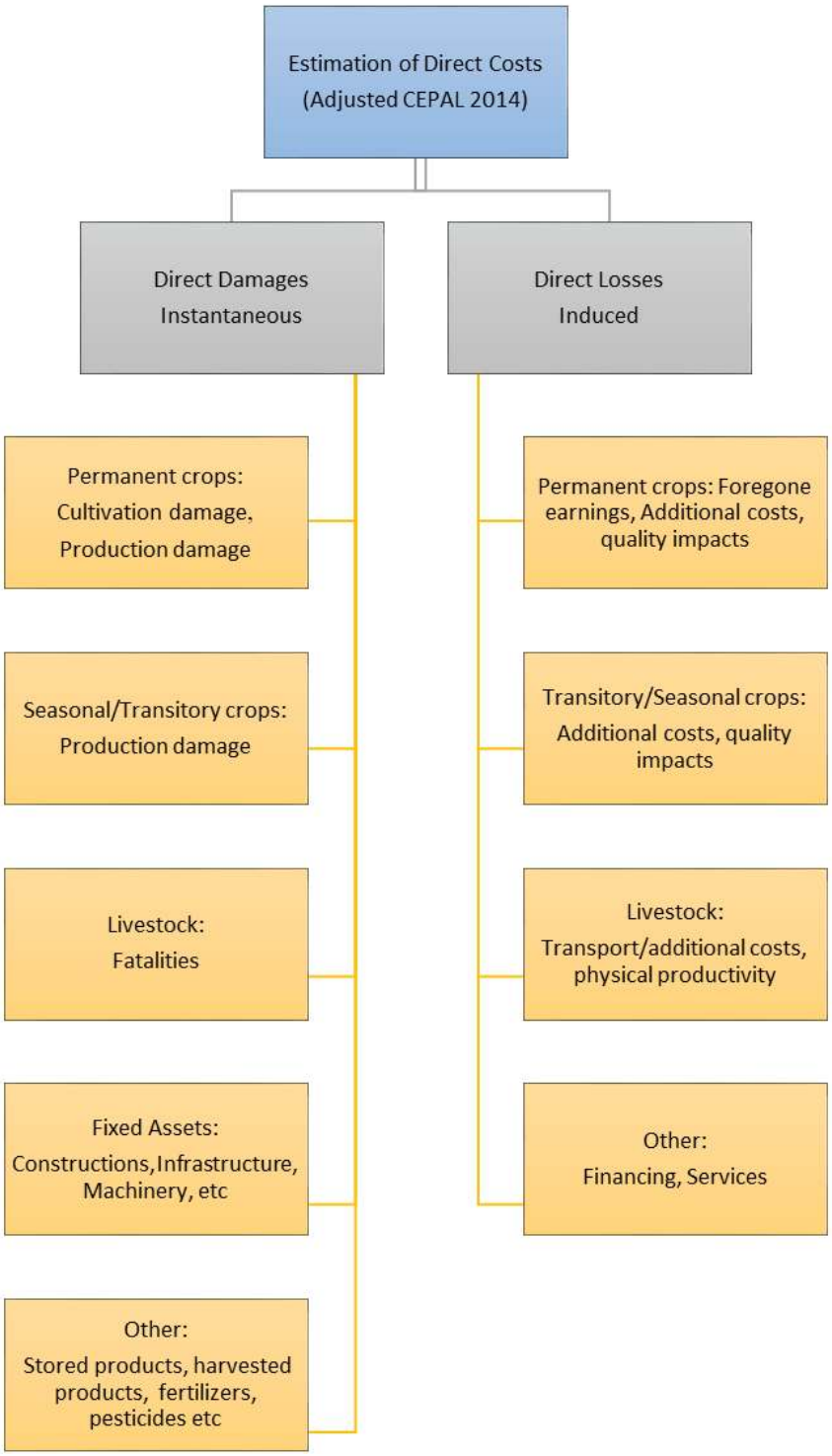

Figure 4: Direct Costs= Direct Damages (Instantaneous) + Direct Losses (Induced) (DC=DD+DL).

DPPi: Damage of the Production of Permanent crop (€) = Gross output value lost= volume of production lost (kg)* product prices(€/kg)

where volume of production lost = affected crop (ha) * corresponding unit yields (kg/ha)

DPHi: Permanent crop Harvesting costs, evaluated using number of days *worker wages (€)

DPIni: Permanent crop Inputs (fertilizers, pesticides, etc) that would have been used if it reached full production (€), evaluated using average market prices

2.1.2. Direct damages on transitory crops

Transitory crops are short-cycle or seasonal crops [16]. In Greece, such crops are rice, cotton, maize, wheat, barley soybeans, potatoes, beans, peas, sorghum, tobacco, tomatoes, watermelons, melons, onions, peppers, cabbage.

Direct Damages on Transitory crops (DDT) are calculated using the equation below:

DDT = $\sum_j (TPj - THj - TInj)$

Where

j: type of Transitory crop and

DTPj: Damage of the Production of the Transitory crop (€) = Gross output value lost= volume of production lost (kg)* product prices(€/kg)

where volume of production lost = affected crop * corresponding unit yields

DTHj: Transitory crop Harvesting cost if it reached full production

evaluated using number of days *worker wages (€)

DTINj: Transitory crop Inputs (fertilizers, pesticides, etc) that would have been used if it reached full production (€), evaluated using average market prices

2.1.3. Direct Damages on Livestock

Direct Damages on Livestock (DDL) comprize all farm animals including poultry and bees. The cost of the damages is evaluated using the number of fatalities:

DDL = $\sum_k DLFk$

Where

k: type of animal and

DLFk: Damage costs of Livestock Fatalities in (€) for animal type k,

evaluated multiplying the number of fatalities by the estimated value

per animal (or swarm) (€)

2.1.4. Direct Damages on Fixed Assets

Direct Damages on Fixed Assets (DDFA) includes l types of assets: infrastructure (roads, bridges), constructions (silos, stables, storage sheds, beehives, buildings), irrigation and drainage systems, machinery (tractors, harvesters, fumigation equipment tools). The cost of the damages is evaluated as follows:

DDA = $\sum_l DFAl$

Where

l: type of asset and

DFAl: Damage costs of rebuilding/ repairing/ replacing of the asset l (€).

Estimation is made using average commercial or insurance values * units affected.

Destruction can be total (replace) or partial (repair)

2.1.5. Direct Damages on Other stored products

Direct Damages on Other stored products (DDO) includes m types of stored products: fertilizers, pesticides, harvested products, animal food, medicine. The cost of the damages is evaluated as follows:

DDO = $\sum_m DOm$

Where

m: type of other stored products and

DOm: Damage costs of replacing Other stored products, m (€). Estimation is made using average commercial or insurance values * units affected.

2.2. Direct losses estimation

Direct Losses are induced and follow the disaster. They are estimated as follows:

DL = Direct Losses (Permanent crops+ Transitory crops+ Livestock+ Other).

2.2.1. Direct Losses on Permanent crops

Direct Losses on Permanent crops (DLP) as described above, include Foregone earnings (LPF), plus Additional costs (LPA), plus lower Yields (LPY) and Quality impacts on fruit or by-products (LPQ), and are calculated using the equation below:

DLP = $\sum_i (LPFi + LPAi + LPYi + LPQi)$

Where

i: type of Permanent crop and

LPFi: Permanent crop Foregone earnings are the estimated profit losses until reaching maturity, in (€) for crop type i, evaluated using three-year average profit margins. Carryover impacts and costs to productive years are approximately 3 years until plants mature [16].

LPAi: are the Additional costs in (€) for cleaning up and debris removal (labor costs), inputs costs, agrochemicals, fertilizers, etc. for the crop type i.

LPYi: the effects of fire on the Yield of the remain crop i, refers to the reduction in the gross output value on crops not directly affected by fire. Comparing average physical productivity data with lower harvest yields and multiplying by the average product price of crop i.

LPQi: the effects of fire on the Quality on the remain crop i, or nearby crops not directly affected by fire, in (€) based on farmers' data. (i.e. smoke taint on grapes destroying wine quality)

2.2.2. Direct Losses on Transitory crops

Direct Losses on Transitory crops (DLT) as described above, include Additional Costs (LTA) and Quality impacts (LTQ) The estimation is calculated as follows:

DLT = $\sum_j (LTAj + LTYj + LTQj)$

Where

j: type of Transitory crop and

LTAj: Additional costs in (€) for cleaning up and debris removal (labor costs), inputs costs, agrochemicals, fertilizers, etc. for the crop type j.

LTYi: the effects of fire on the Yield of the remain crop j, refers to the reduction in the gross output value on crops not directly affected by fire. Comparing average physical productivity data with lower harvest yields and multiplying by the average product price of crop j.

LTQj: the effects of fire on the Quality on the remain crop j, or nearby crops not directly affected by fire, in (€) based on farmers' data.

2.2.3. Direct Losses on Livestock

Direct Losses on Live stock (DLL) as described above, include Transport costs (LLT), Additional costs (LLA), and reduction in physical Productivity (LLP). The estimation is calculated as follows:

DLL = $\sum_k (LLTk + LLAk + LLPk)$

Where

k: type of Livestock and

LLTk: Transport costs for the relocation of Livestock k, new housing costs, labor costs, in (€)

LLAk: Additional costs= clean up and debris removal labor costs + inputs +food+ medication+ irrigation costs, in (€)

LLPk: reduction in physical productivity = estimated loss in meat/milk/eggs/honey production * average product prices in (€)

2.2.4. Other Direct Losses

Other Direct Losses (DLO) include Financing (LOF) and Services (LOS).

DLO = $\sum_l (LOFl + LOSl)$

Where

l: other type of Loss induced by the fire and

LOFl: Financing Losses= any available data or information about additional borrowing costs (€)

LOSl: Services Losses = any available data of information from farmers on extra water or power costs in (€)

3. Conclusion

In this paper, a first attempt was made to develop a method of assessing the cost of forest fires on agriculture in Greece. Methodologies used for floods and natural disasters, are commonly used on estimating the economic impacts in rural areas and agriculture [13, 15, 16, 18, 42, 45, 48, 50]. Therefore, elements of these methodologies were adopted, and adapted in order to calculate the cost of fires.

``Total Cost of Fire'' is defined as the cost of prevention and suppression measures plus direct and indirect costs, similar to Hall's (2014) report [57]. The terminology for

direct and indirect costs varied in the literature. Moreover, it needed adaptation for fire, because its impacts are mainly instantaneous, so we defined as direct costs, a) the direct damages that occur due to the physical contact with fire [44] and b) the direct losses that are induced by fire. Indirect costs include tangible and intangible costs, that are difficult to both identify and quantify, due to lack of data availability and insufficient knowledge of full disaster damage [47]. Direct damages are estimated by an equation that calculates the instantaneous damage in permanent crops, seasonal crops, livestock, fixed assets (infrastructure, construction), machinery and stored products, as in Elliott et al. (2014) [48]. Likewise, the Handbook for Disaster Assessment, by the Economic Commission for Latin America and the Caribbean (ECLAC), estimates farming by damages to infrastructure and lands, as well as losses of transitory crops and permanent crops. Livestock is estimated by damage to total stocks and species, and losses in the production of meat and milk. Direct losses are estimated as direct damages, by a function that calculates fire-induced costs in permanent crops, seasonal crops, livestock and other costs.

The methodology of Posthumus et al (2009) used structured questionnaires [43], estimates of the financial losses and losses of grass production, the minimum agricultural wage rate, machinery costs and extra field operations as estimated by Nix (2006) [58]. For the composition of our estimation model, we will use secondary data, as well as data originated from fieldwork. Primary data, can be collected from interviews and/or questionnaires to farmers affected by the disaster. Agricultural product data can be obtained from Ministry of Rural Development and Food, the Hellenic Statistical Authority, Fire Services of Greece, the Hellenic Agricultural Insurance Organization (ELGA), Regions affected by fire and local associations. The literature review showed that the ex post analysis involving detailed consultation with a representative sample of affected farms, provides a more consistent appraisal [43, 49, 50]. Limitations may include time and spatial boundaries, as well as availability of resources and data [18].

The estimation of the cost of forest fires in agriculture can be useful in both disaster management and planning of preventive measures. These measures can involve financial incentives for farmers to reduce the risk of fire and therefore its cost. Estimation of the economic impacts of fire per crop, per livestock, or per farm in general, can help fire management by designing and planning the agrarian areas adjacent to fire-hazardous areas, choosing the most suitable, durable and economical cultivation, and using the appropriate techniques which will lead to less prone to fire agricultural areas. Additional research suggestions include analysis and comparison of the economic impacts of fires on affected agricultural areas, assessment of the effects of fire on agriculture in the

short, medium and long term, assessment of protection measures, mitigation methods, and costs.

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