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Preliminary Assessment on Agricultural Impact due Frost (Embun Upas) Hazard in Dieng Highland, Central Java, Indonesia**

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ABSTRACT

Dieng Volcanic Highland is one of the most intensive potato agricultural land in Indonesia, as well as frost disaster prone area. Frost indicated by appearance of frozen dew on the ground or vegetation surface due to cold temperatures during dry season. Frost causes damage to leaf tissue in potato plants, resulting crop failure and losses of up to tens of millions. Disaster management needs to be assess in order to achieve Disaster Risk Reduction (DRR) on agricultural land. This research aims to identify frost hazard areas based on local physical characteristics, analyze frost impacts on agricultural land, and provide preparedness recommendation to reduce the impact of frost disasters in Dieng Volcanic Highland. Research was conducted in Dieng Village, Wonosobo and Dieng Kulon Village, Banjarnegara. Method to assess hazard level was performed by spatial mapping technology using ArcGIS and comprehensive analysis using frost assessment through combinations of geomorphology, land use, proximity to water bodies and weather aspects. Dieng Volcanic Highland has a 125.59 ha frost hazard areas, as many as 58.4 ha of hazard areas are dominated by high level, while 24.84 ha are moderate level and 42.95 ha are low level. Cropland dominated by potato commodity has the highest hazard level, frost incident causing agricultural commodities to wither to death so that farmers experience losses. Frost losses in Dieng have a range from 800 thousand rupiah to over 155 million rupiah and only destructive on potato farm. In order to encourage agricultural resilience and reduce the loss of frost disasters, effort of preparedness can be done by passively and actively methods. Passive methods includes site selection, early warning system, shifting commodities, cropland modification, and appropriate calendar planting. Active methods includes frost modification using heaters, blower and sprinkle irrigation, and cropland covering using mulch, plastic or nets.

Keywords: Dieng, Embun upas, Frost, Hazard Mapping, Potato Agriculture, Preparedness.

INTRODUCTION

Indonesia is a wet tropical climate region that has two seasons, rain and drought. Wet tropical climate is characterized by relatively high humidity, heavy annual rainfall and high annual temperatures above 25°C (Bayong, 2004). Wet ropical climatic conditions causing natural ice formation process is very rare formed on Indonesia, but in Dieng Volcanic Highland in Central Java indicate different condition characterized by the appearance of frost that is known in the local language with the term "upas dew". The incidence of frost on the tropical climatic conditions is unique, Synder and Melo-Abreu (2005) explains that frost can occur at many locations, except in the tropics. Kalma *et al*. (1992) mentions that in the sub-tropical region, crop damage due to frost is greatest in comparison to other types of weather disasters. Dieng has an elevation between 2,000 to 2,500 masl. so it has fertile soil and cool climate conditions so that very suitable for agriculture commodities particularly horticulture. Dieng has become national center for potato cultivation with a frequency of two to three times a year (Edy, 2010). However, agricultural production in Dieng on certain conditions can experience

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losses due to the occurrence of natural disasters, among other is frost.

Frost causes tissue damage to thin-leaved plants, thus causing losses in potato farming during the dry season in Dieng. Plants are exposed to frost are characterized by the presence of ice on the leaf surface which further causes the leaves twigs and dry. Efforts to reduce the impact of disasters can be done through a hazard analysis approach. Act Number 24 Year 2007 explains that the distribution of hazards is uneven and needs to be mapped to identify potential areas of loss and to help identify appropriate preparedness directions according to the hazard zoning. This study aims to identify frost hazard areas based on local physical characteristics, analyze frost impacts on agricultural land, and provide preparedness recommendation to reduce the impact of frost disasters in Dieng Volcanic Highland. Through this research is expected to modelling frost hazard distribution through local geomorphology, landuse and climate condition as a basic formulation to provide preparedness plans for vulnerable farmers within frost hazards areas, so that simultaneously support disaster risk reduction (DRR) and creating resilient agriculture in Dieng Volcanic Highland.

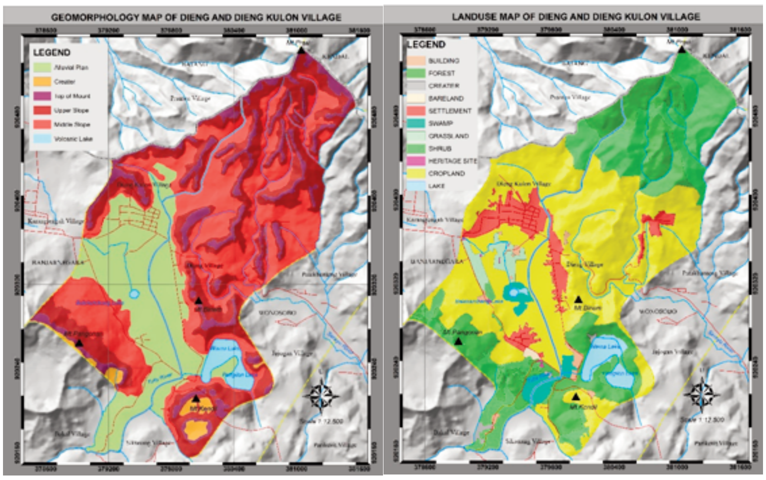
MATERIALS AND METHODS

Study Area

The study was conducted in Dieng Volcanic Highland, in Dieng Village, Kejajar District, Wonosobo and Dieng Kulon Village, Batur District, Banjarnegara. Dieng Volcanic Highland is an active volcanic complex that consist of several medium to old volcanic form units (Verstappen, 2014). The study area in two villages was chosen because the appearance of frost phenomenon on alluvial plains of Tulis River basin (Figure 1). The basin system supports the cold air drainage process which is a key requirement of topographically controlled frost formation controlled by topography (Wang *et al.*, 2016).

Based on geomorphological mapping, the study area controlled by endogenic process of volcanism. It consists of two main geomorphological units (Figure 2.A), i.e., volcanic (red) and fluvial (green). Volcanic zone consists of four cone volcanoes, namely; Prau, Binem, Kendil, and Pangonan. Prau and Binem cones are an inactive volcanic cones, characterized by high erosion incision, sharp slope, and steep valley. Kendil and Pangonan cones still have an active crater. Fluvial Zone consists of alluvial plains and volcanic lakes. Fluvial zone has a flat

Figure 1. Quickbird satellite imagery of study area derived from Google Earth 2017



(A) (B)

Figure 2. (A) Geomorphology map and (B) Landuse map of study area

topography with the main material from slope deposition materials around it and alluvium from river. Distribution of the fluvial zone is located in the middle of the basin surrounded by a cone of volcano, thus resembling a basin which is the suitable location for frost formation.

Dieng was located at 2,000 to 2,500 above sea level with high annual precipitation rate about 2,270–4,835 mm/years. These conditions led to provide very potential land for agricultural cultivation mostly horticulture commodities. Land use mapping (Figure 2.B) shows that the study area is dominated by cropland of 290 hectares or 53 percent of the total area. Cropland dominated by horticulture commodities mainly potatoes, other commodities such as carrots, leek, and cabbage, among other which are fragile commodities damaged by frost. In addition, other land uses identified include swamps, grass, bareland, craters, shrubs, forests, buildings and settlements, archaeological sites, and water bodies in the form of volcanic lake and river, such as Balekambang Lake, Warna Lake, Pengilon Lake and Tulis River.

Research Procedure

The study was conducted during July–September 2017. Materials needed include; ArcGIS software, Geospatial database (contour, river, border of administrative), Quickbird satellite imagery 2017, Geomorphological surveying tools, Termohumidity logger, and Interview guide. Research data obtained through frost hazard mapping, monitoring climate data through logger, questionnaire interview to obtained economic losses data and in-depth interview to farmer community and administrative officer in two villages to understand disaster preparedness aspect. The mapping process was conducted by limiting the study area in two frost affected villages. Geomorphological approach was chosen to mapping frost hazard because the frost formation is closely related to topography condition.

Frost is physically determined by the presence of minimum temperature below 0°C influenced by terrain aspect, i.e., slope and elevation (Kotikot and Onywere 2014; Wang *et al*., 2016). Hansen *et al* (2014) describes another factor that has a strong influence on frost is land cover condition. Areas with high vegetation densities have low frost potential compared to areas with low vegetation densities. Another factor considered is the proximity to water bodies and plant age (Kalma *et al*., 1992). Water has a greater heat capacity than land or air, so the change in water heat is slower than soil or air. Water bodies function to move cold air flow to the lower regions, then area near water bodies tend to have higher thermalconductivity and heat capacity (Synder and Melo-Abreu, 2005). Frost hazard mapping process begins with geomorphological mapping that combining morphology, morphogenesis, morphoarrangement and material data. Morphological unit obtained through delineation process from derived Digital Elevation Model (DEM), ie hillshade, elevation and slope in ArcGIS based on Van Zuidam classification (Mahi, 2015) in Table 1.

Morphogenesis unit (geomorphological process) and morphoarrangement were obtained through stratified sampling of geomorphological field activities for each morphological unit. Unit of material in the form rock formations distribution obtained through Geological Map of Batur. Land use mapping obtained through Quickbird satellite image delineation and stratified field validation. Proximity mapping of water bodies is determined by the buffer technique of river features data on frost affected area through ArcGIS. Mapping result of geomorphology, land use and proximity to water bodies, then processes into overlay and scoring techniques to produce hazard map (Table 2 and Table 3). Frost hazard mapping, temperature monitoring through thermohumidity logger, and interview informations then synthesized

Table 1. Van Zuidam Classification of morphological units

Slope (%)	Unit Morphology
0–2	Plain
3–7	Gentle slope
8–13	Wavy slope
14–20	Hilly
21–55	Mountainous
55–140	Steep mountainous
>140	Very steep mountainous

Source: Mahi, 2015

Table 2. Scoring system for frost hazard mapping

Variable	Parameter	Score
Score of Geomorphology	Plain morphology	2
	Hilly-mountainous morphology	1
Score of Land use	Open/less dense land use types (agriculture based)	3
	Open/less dense land use types (non agriculture based)	2
	Close - high/moderate dense land use types	1
Score of Proximity to Water Bodies	150 meters	3
	100 meters	2
	50 meters	1

Table 3. Total score classification for hazard level

Score	Level of Hazard
<5	Frost Free
5	Low Level
6	Moderate Level
7	High Level

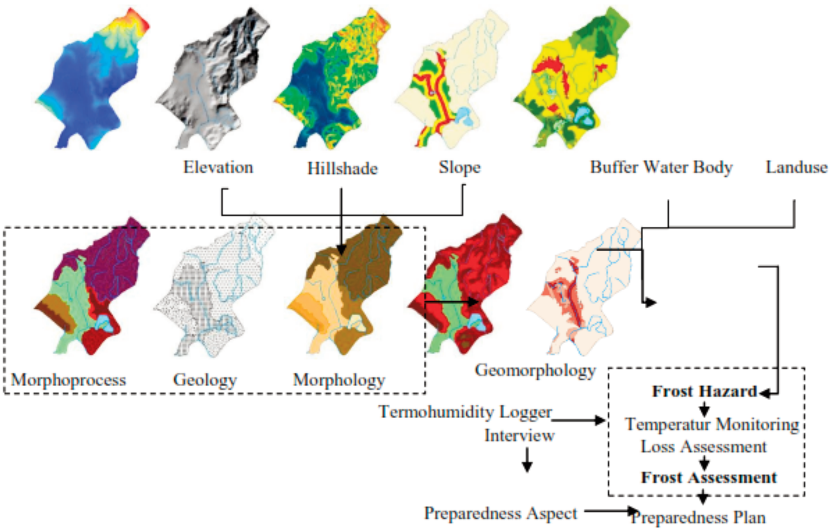


Figure 3. Research procedure on frost assessment and formulating preparedness plan

into frost assessment. Determination of frost disaster preparedness directives formulated by combination of frost assessment result and preparedness aspect obtained by in-depth interview through the leader of farmer's group and head of village administration. The stages of research can be observed in Figure 3.

RESULT AND DISCUSSION

Frost Hazard

Disaster management is a dynamic and integrated process of improving disaster analysis and mitigation, emergency response, disaster rehabilitation (Act No. 24 / Year 2007). An important part of disaster management is the assessment of the hazard level, which means the physical condition of the area that can lead to catastrophic events and potentially cause losses (UNISDR, 2009). Determination of hazard level based on Van Westen and Kingma (2005) consists of four elements, among others; hazard as probability that may occur, hazard probability is limited to specific period of time, hazard probability only applies to a region and hazard events have different intensity and magnitude degree. The result of frost hazard assessment in the map (Figure 4) indicates that cropland dominated by potato commodity has the highest hazard level, frost incident causing agricultural commodities to wither to death so that farmers experience losses. All hazard zones are distributed in alluvial plains on open type of land use in the form of cropland, swamp and grass. The study area has a 125.59 hectare frost hazard areas with varying magnitude hazards. As many as 46.5 percent or 58.4 hectares of hazard areas are

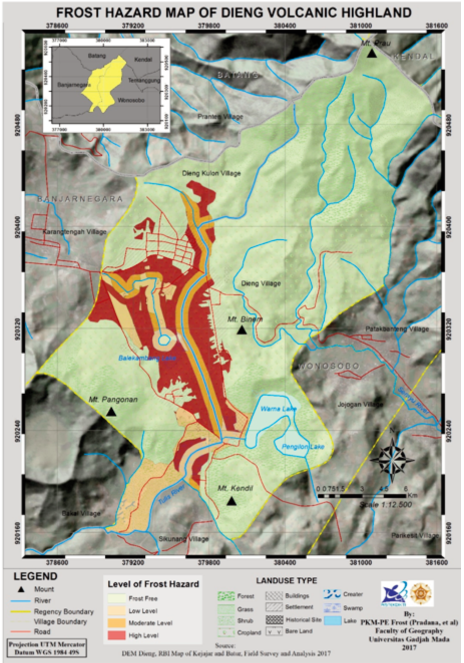


Figure 5. Map of Frost Hazard in Dieng Volcanic Highland
Source: Data Analysis, 2017

dominated by high level, while 24.84 hectares are moderate level and 42.95 hectares are low level.

Low-level zone characterizes frost-affected areas, but do not suffer financial losses due to types of land-use are grass and swamps, then do not produce significant economic value. Moderate-level zone characterize frost affected areas with significant magnitude and impact on agricultural land. The spread of moderate level zones lies on plains and covers area near water bodies up to 50 meters along riparian of Tulis River and around Balekambang Lake. Distance of less than 50 meters allows the influence and spread of water vapor from rivers or ponds to increase the surrounding surface temperature. High-level zone cover an area of plains with distance to water bodies are more than 50 meters. Far distance from water bodies causes cropland experience lower temperature than cropland located next to water bodies because water bodies provide water vapor that increase heat latent near soil surface (Kalma *et al*., 1992). Cropland in high level zone experience a higher frost formation magnitude and is more experience losses (Figure 5).

Frost is used to represent the formation of ice crystals on the surface either by the freezing process of moisture and the process of vaporization into ice (Blanc *et al*., 1963; Bettencourt, 1980 in Ahrens, 2009), but the term frost is widely known as a meteorological phenomenon that results in the plant experiences death or freezing injury. Process of frost formation according to Ahrens (2009) due to the decrease in air temperature so that moisture begins to condense into dew point. Webb and Synder (2013) mentioned that there are three main requirements for frost formation, namely; the surface temperature should be below 0°C or lower, the air temperature is saturated at 0°C or lower, and available condensation core so that the sublimation process can occur. Process of frost formation in the Dieng is strongly influenced by the main parameters, namely geomorphological variation, specific weather conditions, and land use with control parameters

(A) (B) (C)

Figure 5. (A) Low-level (grassland), (B) Moderate-level area (agriculture near water bodies), (C) High-level area (agriculture far away from water bodies)
Source: Pradana, 2017 (Field Documentation)

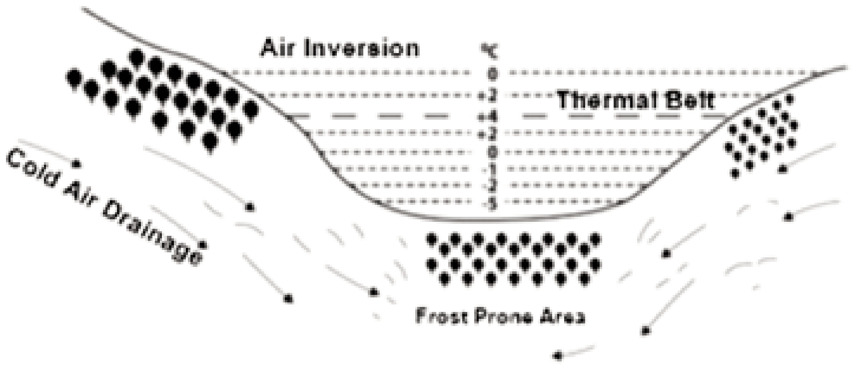


Figure 7. Air inversion process in closed basin system (frost pocket)
Source: Modified from Kalma *et al.* (1992)

such as distance from water bodies.

Kalma *et al* (1992) explains that frost based on the formation process is divided into two types, namely; radiative frost formed by air inversion and adjective frost formed by large-scale cold mass mass movement. Based on the frost formation process, frost occurrence in Dieng is classified into radiative frost that caused by intensive night radiation process from the soil surface that causes surface cooling. This process is associated with antisyclones circulation during the night with a calm wind and without the occurrence of cloud (clear night). Long wave radiation from earth surface release to atmosphere becomes the main factor causing temperature cooling, so that at night there is a big loss of radiation energy.

Formation of radiative frost is due to closed basin topography of study area that surrounded by several volcanic cones. Dalezois and Nastos (2017) explain that closed basin system causes formation of frost pocket in a narrow valley due to radiation release at night so that the soil surface cools faster. Plain areas cools faster because the cold air from the slopes moves to the bottom of the valley due to cold air drainage and encourages warm air rise to form an air inversion process. Air inversion causes air temperature near plain surface or lower elevation to be cooler than air temperature at higher elevations above it.

Frost is formed at night in the dry season (June, July, August and September) when there is a strong air inversion formation so that the temperature near the ground surface reaches 0°C or lower. At night, the above ground and air surfaces lose radiation offset by the loss of long wave radiation due to radiative cooling. Terrain has better radiator properties than the air layer above it, then the faster cooling occurs on the ground surface (Ahrens, 2009). Dry season at night raises high-pressure systems in the lower atmosphere, rarely forming a cloud, marked by clear skies and cloud cover 0/8. The earth's surface releases radiation into space rapidly without any cloud cover as an insulating atmospheric blanket that prevents radiation from escaping into space.

Cooling process on the plains takes place more quickly because the topographic slopes drain gravitational cold air mass to the plains because the cold air mass is heavier. This process forms a warmer air layer above the soil surface called radiation inversion (Figure 6). High pressure prevents the formation of wind movement in the dry season prevents wind formation. Cold air descending from the slopes into the valley is accelerated by the absence of strong wind at night. Without the wind, cold air flow falls faster to replace the warm air

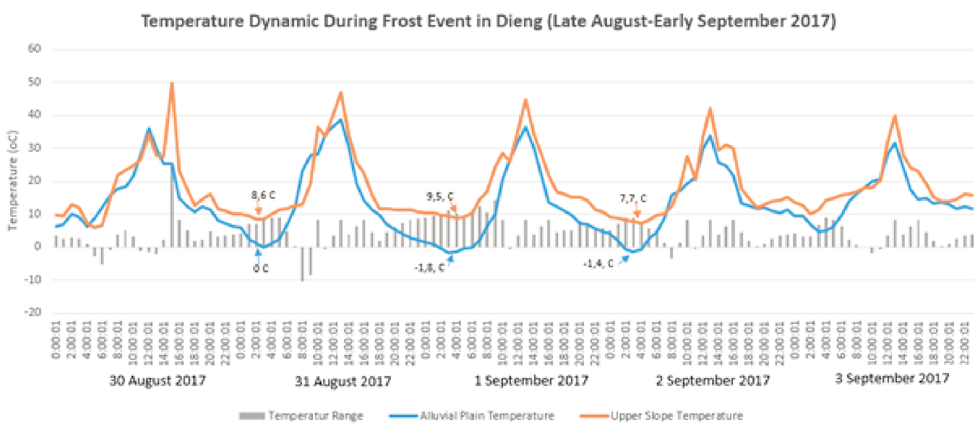


Figure 8. Frost monitoring by termohumidity logger during late August-early September 2017
Source: Data Analysis, 2017

mass on the valley surface. Calm wind also prevents the super-cold surface of the ground from contacting the warmer air layer above it (preventing heat mixing) so that lower elevation undergoes supercooling conditions. The incidence of radiation inversion causes the alluvial plains regions to experience more intensive frost formation than the upper slopes. The slope section experiences a warmer temperature, called a thermal belt that does not allow the formation of frost.

Temperature measurement during July to September 2017 show frost incident only recorded in the early morning of August 31, 2017, then 1 and 2 September 2017. Frost in 2017 occurred with low intensity at the end of dry season because until mid-August 2017 there is still a rain with medium-low intensity. Low intensity of frost in 2017 is characterized by the appearance of a thin layer of ice on the leaf surface with a thickness less than 1cm. Based on different temperature data between alluvial plain and upper slope, frost occurs only on alluvial plains so that temperature monitoring results strengthen the result of frost hazard mapping.

During frost, air inversion can reach 4–11°C between the plain and the slope (Figure 7). The highest air inversion occurred on early morning September 1, 2017 which is the strongest frost event in 2017 reaching 11.3°C, where the terrain temperature reaches -1.8°C while the slope temperature is 9.5°C. Peak of minimum temperature at the time of frost occurred at 3:00 am, at this time there has been a very large radiation release accompanied by the accumulation of cold air mass from the slopes, while in the morning the temperature again warmed up due to increased radiation by the sun. Frost appearance in the early morning is always accompanied by the highest daily maximum temperature of the previous day at 1:00-2:00 pm is very large, reaching 40 - 50 °C. After a very hot day is reached, then the temperature falls down very quickly until it reaches the frost condition in the very early morning (2:00–4:00 am).

Frost Impact on Agriculture

Disaster loss is determined through the presence of the element at risk or can be interpreted as all physical and non-physical assets that are vulnerable to losses in risk systems (UNISDR, 2009). Specifically for the occurrence of frost disasters, the element at risk that is affected is agricultural land, so that all forms of build-up areas and non-economic valuable vegetation cover in the frost-affected plains have no element at risk. Losses from a frost can vary from one plot of cropland to another. Types of agricultural commodities in the study area are dominated by horticulture such as potatoes, carrots, leek and cabbage.

Damage to plants due to sensitive frost usually occurs at temperatures 0°C to below -5°C, but damage to plants very strongly determined by the level of plant resistance to cold temperature conditions (Synder and Melo-Abreu, 2005; Webb and Synder, 2013). Based on Table 4 which explains the criticality of cold temperature of plants to frost, it is known that potato has the highest level of vulnerability. Results of community interviews explain that vulnerable commodities are generally potatoes, while other commodities tend to resistant with frost hazard. This is due to the critical temperature of potato are at a warmer degree than other commodities so that more easily damaged when exposed even to low-intensity frost.

Formation of ice on plants can destroy both intracellular and plant extracellular tissues (Synder and Melo-Abreu, 2005). Levitt (1980) explains that plant cells die when icy growth occur in the outer cell portion. The growth of ice leads water to evaporate from liquid phase inside the cell through the semi-permeable cell membrane to form an ice layer outside the cell and thus potentially lead to cell damage. When water is lost from within the cell, there is an increase of solution concentration and reduces the chance of the cell to freeze. Crop damage is also caused by increased of water pressure around the cell due to the formation of an extracellular ice sheet (Webb and Synder, 2013). Plants with thin leaves such as potatoes are vulnerable to destroy so the potential for agricultural losses is higher than other commodities.

Frost occurs almost every year during dry season, recorded on August 14, 2015, destroying about 100

Table 4. Critical temperature of agriculture commodities

Commodities	Binomial Name	Critical Temperature (°C)
Carrot	*Daucus carota*	-7
Cabbage	*Brassica oleracea*	-5
Leek	*Allium porrum*	-6
Potato	*Solanum tuberosum*	-0,8

(A) Frost: August 2015 (B) Frost: September 2017

Figure 8. (A) Strong intensity frost (2015): frost thickness more than 3cm, potato experienced death and rot, while leek not damaged,(B) Low intensity frost (2017): frost thickness less than 1cm, potatoes withered leaves, leek does not wilt
Source: Antara News, 2015, Rappler, 2017 and Pradana, 2017 (Field Documentation)

hectares of farmland in Dieng and Dieng Kulon villages with losses reaching 15 million rupiah per hectare (Andrianto, 2015). On August 24, 2015, frost resulted in losses reaching 10 million rupiah per hectare, while on 3 August 2016 the area affected almost 25 hectares and losses occurred in potato fields aged under 60 days (Huawe, 2016). Newest in early September 2017 frost resulted in leaf wilting on a two-hectare potato field in Dieng Kulon (Ridho, 2017). Potato plants damaged by frost are characterized by wilting, twig and dry condition even blackened (Figure 8).

Based on interviews on farm plots, frost losses were found only in potatoes, while cropland with carrot, leek and cabbage commodities did not suffer losses. As many as 97.3 percent of agricultural land in frost danger areas are planted with potato commodities. Reason most farmers choose potatoes because the selling price is more competitive than other commodities. Frost losses in Dieng have a range from 800 thousand rupiah to over 155 million rupiah (Figure 9). Level of loss in the potato field varies greatly depending on the age of planting. Potato crops in Dieng are generally planted for 4 months and can be planted throughout the year, so that during the frost period (July–September) each plot of land has a variation of potato planting age (phenological stage). Younger potato plants (1-2 months, less than 60 days) are more vulnerable to damage than older plants (3–4 months, more than 60 days) because they have very soft tissue conditions that are sensitive to frost impact.

The rate of losses can be as high as 20 up to 100 percent indicating that farmers fail to harvest as the total capital or investment lost by frost phenomenon. When potato planting period is still reaching 1–2 months at the time of frost period, potatoes can experience 100 percent crop failure from normal results. Crop failure is indicated with blackened leaves and potato tubers are still so small that it is not worth for selling. When reaching the age of 3 months (adult age) during the frost period, potato farmland will experience a 50 percent crop failure, some potato tubers can still be sold. If the period of planting potatoes has reached the age of 4 months

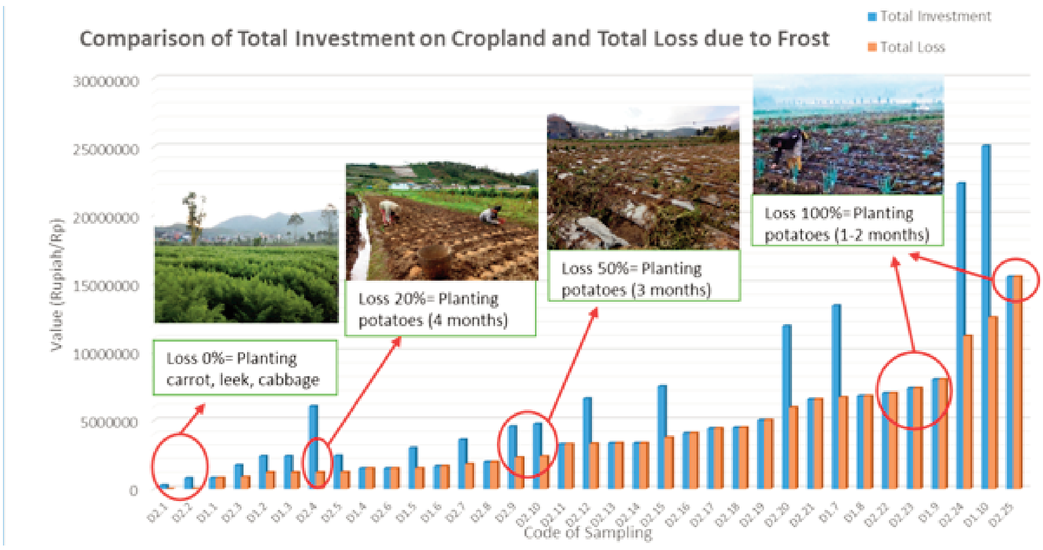


Figure 9. Comparison of Total Loss in Different Commodities Phenological Stage
Source: Data Analysis, 2017.

(harvest age) during the frost period, then the loss is only about 20 percent, in this condition the potato has been mature enough so that the selling price can still compete in the market.

Preparedness Plan

High Impact on agricultural losses due frost (embun upas) not only determined physically by high level of hazard exposure. Pradana et.al (2018) explain that total losses also determined by high level of farmer's vulnerability that comes vulnerable commodity types, i.e potatoes, low economic aid and social organization to reduce frost risk as well low coping capacity as one of the most sensitive criteria determining level of vulnerability. Further appropriate preparedness need to be taken in order to reduce losses due to frost and achieve disaster resilience agriculture community in Dieng Volcanic

Highland. Dieng Vulcanic Highland has a 125.59 hectare frost hazard areas and losses can reach 800,000 rupiah up to over 155 million rupiah, so effetive preparedness effort need to be done to increase the capacity of agricultural land so as to encourage resilience agricultural systems and reduce the loss of frost disasters. Preparedness is a series of disaster risk reduction efforts both through physical action and increasing the ability to cope with disasters (Act No. 24/Year 2007). Recommended preparedness can be done passively and actively, among are:

1. Passive preparedness includes methods focussing on land management efforts during frost season to reduce losses, several recommendations include;

a. Site selection through chooses the exact location of the farm based on frost hazard mapping results. Farming during the frost season is recommended not to be done on terrain in the closed basin system. Farming is good to locate near water bodies because large water bodies upwind tend

1) Frost appears only during the peak of the dry season (June–September)
2) Frost appears when there is no rain or drizzle
3) During the day before the frost is marked with very hot temperature, maximum temperature can reach in the range 35–40°C
4) Late afternoon of frost is marked by the appearance of a low elevation fog that covers the plains
5) Night of frost is marked by bright sky (no cloud covers) and quiet winds (less than 5m/s)
6) Very large air inversion reaches more than 5°C at a difference of 45 meters altitude between terrain and slope;

to diminish frequency of frost events

b. Early warning system through identifying frost occurrence based on logger monitoring, some signs of frost occurrence that can be observed among others;

c. Shifting commodities, mostly to non-potato farming or non-vulnerable frost crops, i.e. carrots, leek, cabbage, or other commodities so that the level of loss can be reduced. Consideration of shifting commodities should also be based on the agricultural economy aspect because the competitiveness of potato commodities is much higher than non-potato commodities.

d. Cropland modification, which is by implements intercropping on potato farms with other commodities to deal with farmers who still want to plant potatoes during frost season. Intercropping can be done by planting potatoes with frost-resistant or non-potato commodities on the same farm, so that crop losses on one plot of land can be reduced.

e. An appropriate planting calendar, can be done by ensuring that potato planting during the frost season has reached ready to harvest stage (4 months), so the level of loss can be reduced.

2. Active preparedness includes methods to modify frost point temperatures and first accompanied by observation of signs frost occurrence (Synder and Melo-Abreu, 2005), among others

a. Frost modification, which is done by directly preventing process of frost formation by understanding the characteristics of frost occurrence requirements. Frost modification are effective protection that can be applied to potato fields, but require higher financing than other methods, among others are;

1. Provide temperature warming near the ground by installing a firebox/heaters/furnace at night, to prevent the temperature from cooling below frost point and interfere formation of air inversion.
2. Install a wind blower on farmland to generate wind flow in the valley, so as to produce heat mixing between mass of cold air near surface with warm air above it and prevent frost formation.
3. Conducting spraying of potato land at dawn with sprinkle irrigation system. Spraying at

the time of frost formation can interfere with the process of occurring frost.

b. Cropland covering is done by covering potato fields with mulch, plastic or nets, thus preventing moisture contact in air with super-cool soil or vegetation surfaces. Covering can be done at an altitude of 30 cm until 1 meter above ground level in the afternoon before frost event and can be released in the morning after the frost event (Synder and Melo-Abreu, 2005).

CONCLUSIONS

Frost is physically determined by the presence of minimum temperature below 0°C which is controlled by geomorphological condition, land cover and proximity to water bodies. Dieng volcanic highland has a 125.59 hectare frost hazard areas with varying magnitude. As many as 46.5 percent or 58.4 hectares of hazard areas are dominated by high level, while 24.84 hectares are moderate level and 42.95 hectares are low level. Cropland dominated by potato commodity has the highest hazard level, frost incident causing agricultural commodities to wither to death so that farmers experience losses. All hazard zones are distributed in alluvial plains on open type of land use in the form of cropland, swamp and grass. Frost losses in Dieng have a range from 800 thousand rupiah to over 155 million rupiah and only destructive on potato farm. The rate of losses can be as high as 20 to 100 percent from total capital or investment depend on the age of the potato plant, younger potato experience more losses up to total failure. In order to encourage agricultural resilience and reduce the loss of frost disasters, effort of preparedness can be done by passively and actively methods. Passive preparedness includes site selection, early warning system, shifting commodities, cropland modification, and appropriate planting calendar. Active preparedness includes frost modification using heaters, blower and sprinkle irrigation, and cropland covering using mulch, plastic or nets at an altitude of 30 cm until 1meter abouve ground level.

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