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A Research on Investigation of the Application Possibilities of Direct Drill Machine with Liquid Fertilizer Assembly for Grain Planting Stubble*

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ABSTRACT

In this study, it is aimed to develop a direct drill machine, which can sow directly without cultivating the soil after the sunflower harvest in the Thrace Region, by applying liquid fertilizer, instead of the granular fertilizer used in the current sowing machines, and applying liquid fertilizer with sowing. The field work of the grain sowing machine directly to the sunflower stubble with liquid fertilizer device was developed in Altayoglu Agricultural Machinery Food Agriculture and Farmer Ind.Ttrade.Co.Ltd. and It was carried out in the production areas of the company. The performance of the direct drill machine was determined from the vegetative and generative characteristics of the sowed plant length, plant wet root weight, plant height, spike length, grain weight in main spike, thousand grain weight and yield values. Liquid fertilizers applied directly by grain direct drill machine effect on wet root weight, spike length, grain weight in main spike and thousand grain weight were found to be statistically significant. However, the effect of applied liquid fertilizer applications on plant length, spike length, and yield was found to be statistically insignificant. Among the liquid fertilizers applied at the same dosages, the highest yield was found to be 646.91 kg/da in liquid fertilizer B and the lowest yield was 593.07 kg/da in conventional method.

Keywords:Cereal, Direct drill, Liquid fertilizer, Wheat, Sunflower, Sowing machine

I. INTRODUCTION

Agricultural management practices that produce economic crop yield while improving soil health are the keys for sustainable production systems [1]. While there is research documenting benefits of conventional tillage (CT), including field workability, weed suppression, and crop productivity, other research shows that CT reduces soil biodiversity, degrades soil structure, accelerates soil organic matter (SOM) loss, affects reactive nutrient cycling, and consequently, diminishes soil health [1], [2], [3]. The reactive nitrogen (N) and phosphor (P) fertilizers applied with CT are responsible for reduced agroecosystem services.

In recent years, irregular rainfall events caused by global warming have caused droughts to intensify.Therefore, conserving water in the soil and reducing energy costs has become a priority in agricultural production.For this purpose, reduced tillage and no-tillage methods in agricultural production have become widespread in developed countries in recent years. These techniques increase the organic matter content in the soil, reduce the density of the soil due toless fieldtraffic, and

minimize water and wind erosion because direct cultivation methodsleave more plant residue on the surface.

Fertilizers falling on the soil together with the seeds in the mentioned precision sowing machines manufactured in the current technique are in granule or micro granule form. In this case, said granular fertilizers in the structure, the development of the seedtoxicto act and push the root of the effects of germination in terms of water uptake to be able to.The mentioned granular fertilizers can also damage the microorganisms in the soil.

The liquid fertilizer spreading system, which is a new system that can be an alternative to the granule fertilizer system in existing seeders, was placed on the machine, and the applicability of a new machine that can both directly sow and have liquid fertilizer disposal feature was investigated. In this study, it is aimed to examine the application possibilities of direct sowing machine with liquid device that can directly sow without cultivating the soil in grain sowing after sunflower harvest in Thrace Region. Theplant wet root weight, plant height, spike length, grain weight in the main spike, thousand kernel weight and yield values were determined from the vegetative and genarative characteristics of the performance of the direct seeder.

II. MATERIALS AND METHODS

2.1.Material

2.1.1. Direct drill machine with liquid fertilizer

The design and production of the sunflower stubble direct grain planter with liquid fertilizer device, which constitutes the main material of this research,was carried out in the Altayoglu Agricultural Machinery Food Agriculture and Farmer Ind.Ttrade.Co.Ltd. (Figure-1).Theliquid fertilizer system of themachineis given in Figure-2and its general dimensions are given in Table-1.

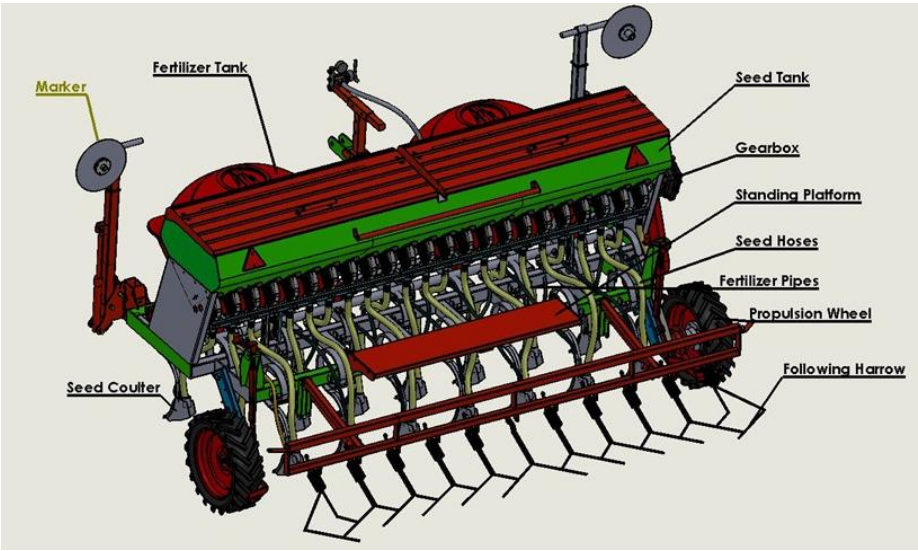

Figure 1. Direct drill machinery with liquid fertilizer systems

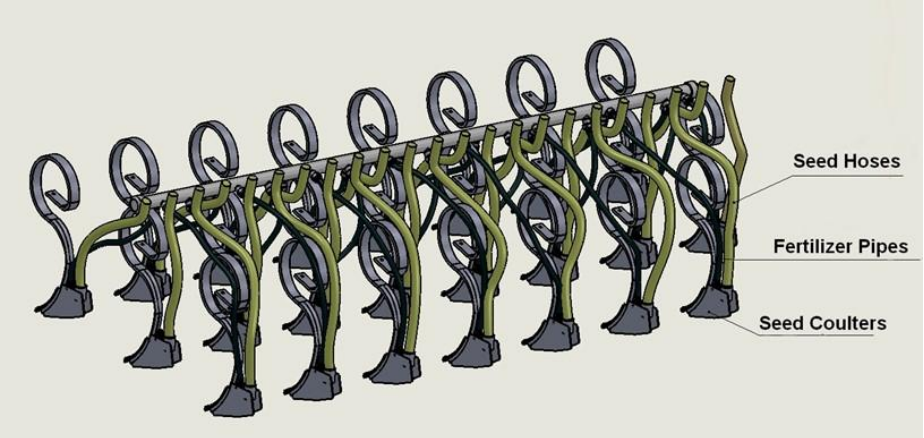

Figure 2.The liquid fertilizer system of the mulch direct grain planter

Table-1 General dimensions of the driect drill machine

General Dimension	Road Position	WorkingPosition
Length (mm)	2400	2400
Width (mm)	3250	5650
Height (mm)	1750	1500
Weight(kg)	880	
Workingwidth (mm)	2375	
OperationSpeed (km/h)	5-7	
Powerrequired (hp)	>95	
3 PointLinkageCategory	Category-II	
Number of openerseedbed	19	
Openertype	Spring Type	
Distancebetweentheseedcoulters (mm)	125	
Grain tank capacity (liter)	373	
Fertilizer tank tapacity (liter)	393	

2.1.2.Site description

Field trials of this study were carried out Tekirdağ Province, Hayrabolu District, İlyas District during the 2019-2020 production season.Within the borders of Tekirdağ Province, Hayrabolu District is located between 41° 12′ 47″ north and 27° 6′ 24″ east longitudes. Hayrabolu district is 60 meters above sea level.The location of the field where field trials are conducted is between 41° 20′ 74″ north and 27° 06′ 47″ east longitudes.

The soil in the experiment field was a clay soil with a texture of 35,22% clay, 34,03% silt and 30,75% sand, well drained and the available waterholding capacity within 1.20 m of the soil profile isapproximately 0.18 m [4]. Field capacity was %39,72 and infiltration rate was 10,45 mm/h.

The climate of Hayrabolu is characterized by Mediterranean type with mild and rainy winters and hot and dry summer at the coast while continental type prevails inside.

2.1.3. Features of the wheat variety

TheEnola variety, whichis mostlypreferred in clay-silt and sandysoilsin the Thrace Region, was used as plant material in the experiment.It is a kind of white spike with awn, ears are long and semi-inclined structure.Plant height is 80-85 cm. Its grain is very large, red in color and hard-semi-hard structure, it is a medium early variety. It is a very strong variety, high yielding, high quality,

resistance to diseases, frost and drought.It is recommended to be planted in all kinds of soil structures and its yieldpotential varies between 450-850 kg / da. The amount of seed to be used varies between 20-22 kg per decare (Anonymous, 2019)

2.1.4. Properties of liquid fertilizers

In the field trials of the direct seed drill, four different liquid fertilizers available on the market were used only during planting. Different carriers widely used in Turkey fluid produced fertilizers A, B, C, D encoded and the traditional method used in wheat farming in the Thrace Region is shown as GLN. Liquid fertilizers used in the study are organic matter 20%, total nitrogen 2%, water soluble potassium oxide (K2O), free amino acid 1%, maximum EC 4 (dS/ m) and pH between 5 and 7%.

2.2.Method

2.2.1.Plant Characteristics Measurements

In the experiments, the spraying was done against weeds at the appropriate period, and the application of nitrogen fertilizer (5 kg pure phosphorus) over 15 kg / ha, kg pure nitrogen was applied in 2 periods, at the beginning of the stem and before the heading.The following measurements and observations were made on the plants in the plot in the field during the trial.

Wet root weight: After the plants are harvested, the soil on the roots will be washed away and then weighed in gram after being kept in the shade between twopapertowelsto remove the water [5].

*Plant height:*Ten plants randomly selected from each plotwere averaged by measuring the distance between the root collar and the top of thespikeand the plant height was recorded in mm[5].

*Spike length:*Ears on the main stem of 10 plants randomly selected from each plot were measured and averaged, the spike length was found in mm[5].

Kernel weight in the main spike: The grains in the main ear of the plants taken randomly from each plot were weighed and averaged and determined as gram[5].

*Thousand grain weight:*Four seeds from each of the harvested parcels will be randomly taken from 100 seeds, weighed separately, averaged and converted to 1000 grain weight and determined in grams [5].

Yield: In order to determine the effects on the yield of liquid fertilizers used in different types, the yields (kg/da) were determined by harvesting the plants in 1 m^2 in the middle parts of the plot in three replications during the harvest period[5].

2.2.2. Application Norms of Fertilizers

In the experiment, 4 liters of liquid fertilizer was applied per hectare during planting in liquid fertilizer applications.The traditional method is that 20 kg of NPK (20-20-0) chemical fertilizer is laid per decare during planting. After planting, 46% Nitrogen (20 kg / da) was given as the second fertilizer in all applications, and 20 kg 26% Ammonium Nitrate (NH_4NO_3) fertilizer was given per decare in the third application.

2.2.3.Statistical analysis and experimental design

A randomizedcompleteblockdesign (RCBD) withthreeblockswasused in thisexperiment. Eachblocktaken as treatment had threeplotsconsisting of threereplications (Figure-3). One-wayanalyses of variance (ANOVA) wereperformedusingSPSS software (Version 12:00; Chicago, IL, USA). Duncan'sMultipleRange Test at $p \leq 0{,}005$ wasusedtocomparethemeans of theobtainedresults in thisresearch(Düzgüneş et al. 1987).

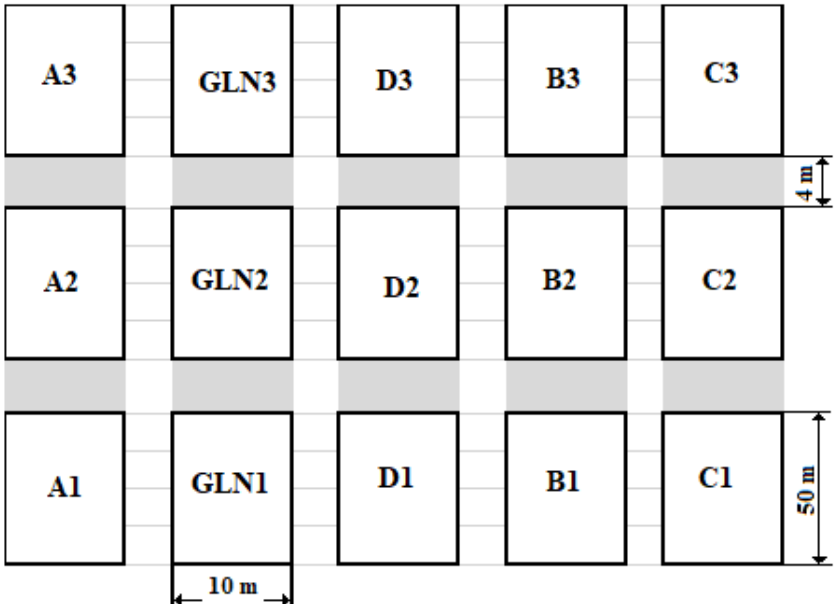

Figure-3. Experimental design for liquid fertilizer applications

III. RESEARCH RESULTS AND DISCUSSION

3.1. Wet root weight

The difference between the values related to the wet root weight according to the liquid fertilizer types appliedwas found to be significant as statistics. The maximum wet weight of B fertilizer, which is one of the liquid fertilizer producers, was determined in the traditional method with thesame dose of 7.30 grams and at least 4.53 grams (Table-2).When the wet root weights were examined, liquid fertilizers given during plantinghad a positive effecton the germination of the plant and the development of the roots. Thirumaran et all. (2009) compared liquid fertilizer applications with chemical fertilizer applications.According to the results, they found that liquid fertilizer applications increased the length of the plant roots. With this study, liquid fertilizer application also had a positive effect on root weight.

Table-2.Descriptive statistics on damp root weight

Liquid Fertilizers	Mean ± SS	S Error	Min	Max	P
A	5,07±0,38ab	0,22	4,8	5,5	0,000
B	7,30±0,53a	0,31	6,9	7,9	
C	5,67±0,57a	0,33	5,2	6,3	
D	5,50±0,26a	0,15	5,2	5,7	
GLN	4,53±0,21b	0,12	4,3	4,7	

*Values with the same letter are not significantly different at the 0.05 levels.

3.2. Plant height

In the experiments, the differences between the methods applied in terms of plant height were found insignificant.However, the highest effect on the plant heightwas obtained in theapplication of B fertilizer and the least effect on the plant height was obtained in theapplication of A fertilizer(Table-3).Liquid fertilizer types and traditional methods have the same effect on plant height.Matsi et al. (2003) determined that liquid fertilizer applications did not affect seed germination in their study.

Table-3.Descriptive statistics for plant height

Liquid Fertilizers	Mean ± SS	S Error	Min	Max	P
A	738,33±31,34a	18,10	712,0	773,0	
B	802,00±58,62a	33,84	736,0	848,0	0,738
C	766,00±100,64a	58,11	653,0	846,0	
D	783,00±115,52a	8,96	768,0	799,0	
GLN	742,33±84,44a	18,75	645,0	796,0	

*Values with the same letter are not significantly different at the 0.05 levels.

3.3. Spikelength

The effect of liquid fertilizer applications on spike length, which is effective on yield, was found to be statistically significant.The maximum spike length was obtained from Bfertilizerwith 98.83 mm and at least 82.23 mm in traditional method (Table-4).The effect of other fertilizers A,B,C, and D fertilizers on the spike length was the same (Figure-4).

Table-4. Descriptive statistics for spike length

Liquid Fertilizer	Mean ± SS	S Error	Min	Max	P
A	89,13±13,49ab	7,79	80,9	104,7	
B	98,83±10,37a	5,99	92,6	110,8	0,208
C	85,93±4,29ab	2,48	82,7	90,8	
D	88,13±2,81ab	1,62	84,9	90,0	
GLN	82,23±2,16b	1,25	80,7	84,7	

*Values with the same letter are not significantly different at the 0.05 levels.

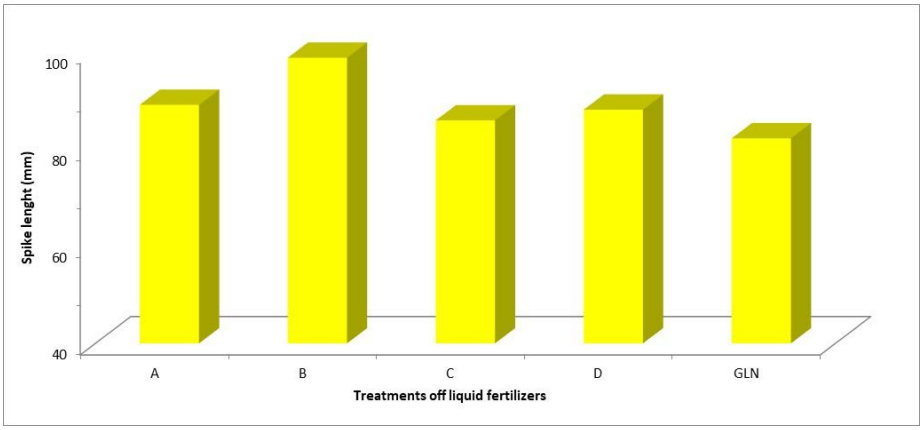

Figure-4.The effect of liquid fertilizers on spike length

3.4. Grain weight in main spike

As a result of the statistical analysis made in terms of the grain weight in the main spike, which is one of the parameters affecting the yield,it was determinedthatthedifference between fertilizersis important.The results descriptive statistics for the difference is not significant (Table-5).Liquid fertilizer applications were found in the same group and the maximum spike length was in B fertilizer with 1.90 grams, while the traditional method was in a different group and the grain in the spike was found to be 1.44grams (Figure-5).Armstrong et al.(1993) found in a study they conducted in Russia that liquid fertilizers increased the seed weight in the spike [10]. Nankova et al.(2004), in their study, it has been observed that cereals tend to be more willing to apply liquid and equivalent solid fertilizers during the vegetation period and tend to increase the growth rate [11]. Similar results were

obtained in this study.As a result of liquid fertilizer applications, it had a positive effect on grain weight in the main spike.

Table-5.Descriptive statistics for grain weight in main spike

Liquid Fertilizer	Mean ± SS	S Error	Min	Max	P
A	1,84±0,056a	0,03	1,8	1,9	
B	1,90±0,06a	0,03	1,9	2,0	0,014
C	1,65±0,28ab	0,16	1,4	2,0	
D	1,82±0,09a	0,05	1,8	1,9	
GLN	1,44±0,05b	0,03	1,4	1,5	

*Values with the same letter are not significantly different at the 0.05 levels.

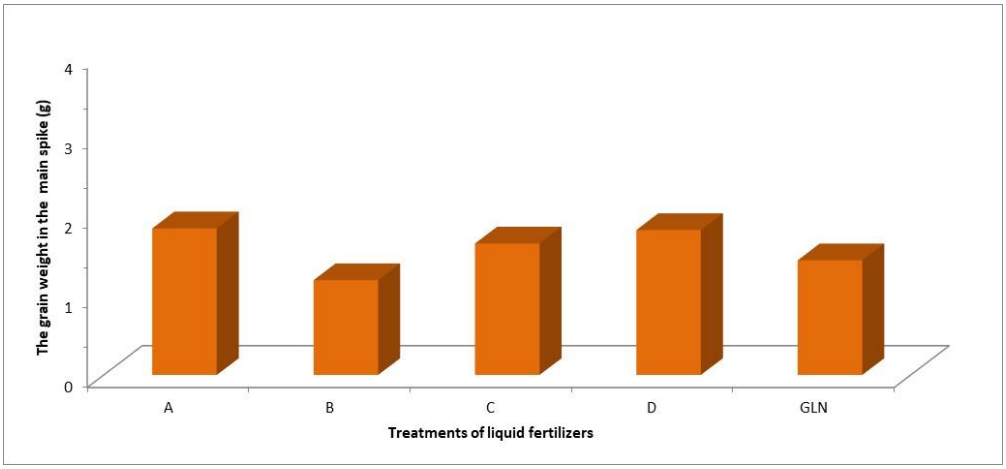

Figure-5. The effect of liquid fertilizers applied on the grain weight in the main spike

3.5. Thousand kernel weight

The results of thousand grain weights obtained, it was found that the difference between the applied methods is significant.Statistical data of the effectofliquid fertilizer types and traditional methods on thousand grain weight are given in Table-6.In this study, the highest thousand grain weight was obtained in the application of B fertilizer (41.96 g), and the least in the method where C fertilizer was applied (41.39 g).When the studies were examined, it was observed that similar results were obtained. Shahet al.(2013) found that it increased the weight of 100 seeds in a study they conducted.

Table-6.Descriptive statistics for thousand grain weight

Liquid Fertilizer	Mean ± SS	S Error	Min	Max	P
A	41,82±0,58a	0,33	41,23	42,39	
B	41,96±0,38a	0,21	41,56	42,32	0,457
C	41,39±0,17b	0,09	41,24	41,57	
D	41,64±0,36b	0,21	41,25	41,97	
GLN	41,59±0,29c	0,17	41,38	41,92	

*Values with the same letter are not significantly different at the 0.05 levels.

3.6. Yield

The difference between the liquid fertilizer types whose effects on yield, which is the most important parameter, were examined, was not found to be statistically significant. Among the liquid fertilizers applied in the same doses, the highest yield was found in B fertilizer (646.91 kg/da), and the lowest yield was obtained in the traditional method (593.07 kg/da) (Table-7).

Table-7. Descriptive statistics for thousand grain weight

Liquid Fertilizer	Mean ± SS	S Error	Min	Max	P
A	633,51+56,67a	32,72	569,4	676,9	
B	646,91+85,56a	48,59	561,5	729,8	0,863
C	643,13+85,56a	49,40	567,3	735,9	
D	624,40+51,61a	29,80	565,0	658,3	
GLN	593,07+44,03a	25,42	542,6	623,7	

*Values with the same letter are not significantly different at the 0.05 levels.

Liquid fertilizers given to the seed bed during the cultivation of grains had a positive effect onsome vegetative and generative characteristics of theplant.It was found that the effect of liquid fertilizers on the yield parameter, which is important in crop production, is not significant (Figure-6).When the liquid fertilizer studies were examined, they emphasized that the liquid fertilizer form has an important effect on plant root development. Matsiet al.(2003) found that liquid fertilizer applications did not affect seed germination, but did affect grain yield during the growth phase in a study they lay in.Shahet al.(2013) in a study of grain yield of 7.5% and 5.0% at concentrations. Empirical yield of 19% of the mother liquid manure, 74 and found that increased 3.16%. They emphasized that the increase in yield was due to increases in spike, spike weight, spike length and thousand grain weight[12]. Panayotova and Stoyanova (2014)hectare to 5 liters ofwaterIVfertilizer (maxgrow) application is a beneficial effect on yields compared to data they obtain in wheat cultivation, and they have determined (Panayotova and Stoyanova (2014) determined that IV fertilizer (maxgrow) application to 5 liters of water per hectare has a beneficial effect on the yield according to the data they obtained in wheat cultivation.) [13]. Similar results have been found and have also been identified by researchersin other studies [13-18].

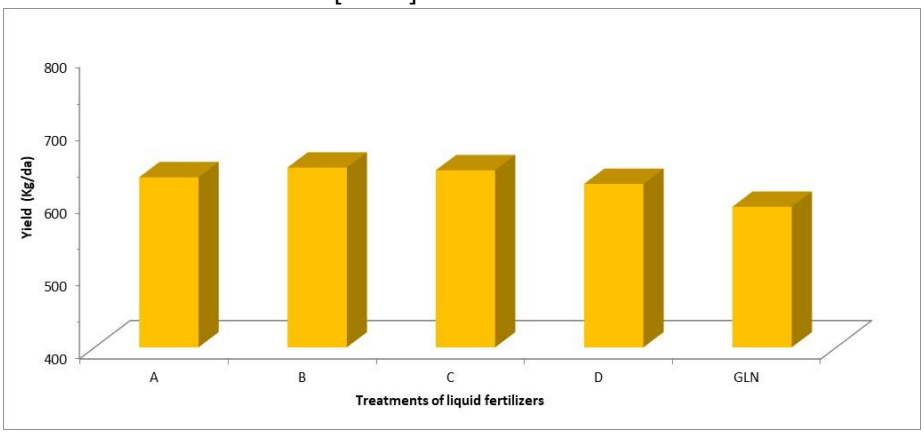

Figure-6. The effect of liquid fertilizers on the thousand grain weight

IV. CONCLUSION AND RECOMMENDATIONS

The applicability of a direct sowing machine in agriculture has been investigated by placing a liquid fertilizer spreader device instead of granular fertilizer used in existing sowing machines, which can directly sow without cultivating the soil after sunflower harvest in the Thrace Region. The effects of the developed planter on the vegetative andgenarativecharacteristics of theplanted plant on theplant wet root weight, plant height, spike length, grain weight per spike, thousand kernel weight and yield values were investigated. As a result of the experiments, the following results were obtained.

1- The effect of liquid fertilizers produced in different types on the wet root weight of the plantwas found tobestatistically significant. The highest wet root weight was determined with B fertilizer with 7.30 g and with the traditional method with the lowest 4.53 g.

2-The liquid fertilizers applied had no effect on the plant height.With liquid fertilizer application, the highest plant height was obtained in B liquid fertilizer (802.00 mm) and the lowest plant height was obtained in A liquid fertilizer (738.33 mm) application.

3-It has been determined that liquid fertilizers arestatistically significant in terms of spike length.In line with the results obtained, more spike length 98.83 mm was obtained in B liquid fertilizer application and at least 82.23 mm in traditional method.

4- It was observed that the difference was statisticallysignificant interms of grain weight in the main spike.The grain weight in the main spike was found to be maximum 1.90 g in B liquid fertilizer, whereas the traditional method was 1.44 grams.

5- When the weight of thousand kernels was examined, it was found that the effect of liquid fertilizer applications was significant. The highest thousand grain weight was obtained in B liquid application with 41.99 g and the lowest in C liquid fertilizer application with 41.39g.

6- The effect of liquid fertilizer applications on yield wasstatisticallyinsignificant.Among the liquid fertilizers applied in the same dosages, the highest yield was found as 646.91 kg/da for B fertilizer and the lowest yield was determined as 593.07 kg/da in the traditional method.

Advantages of using direct drill machine with liquid fertilizer system in line with the results obtained;

- Preventstoxiceffects on seeds,
- Itprotects the seed against pests and diseases in theseedbed,
- Increasing the density of microorganisms in thesoiland thus increasing microbiological activities and increasing microbiological activity in the soil has a positive effect on productivity,
- Since the fertilizer is inliquid form, plant nutrients are more easily absorbed by plants,
- Byaccelerating the germination ofplants, the germination day is shortened.
- Provides the development of roots.
- Provides fuel savings.
- Stubbleroots hold the soil, reducing the damage of rainfall and wind to the soil surface.
- It prevents waterand wind erosion.
- It has eliminated the problem of soil compaction as the field traffic is reduced.

The disadvantages of using direct drill machine with Liquid Fertilizer System in line with the results obtained;

- Powerful tractors are needed to use the seed drill.
- Foreignincreasing weed density.

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Analysis of the Concrete Compressive Strength of Wailawa River to Withstand Partial Landslides on The Slopes of Mount Kohara, Tawiri Village, Ambon City

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Ambon - Indonesia

ABSTRACT

Landslides that occur on the slopes of Mount Kohara generally occur during the rainy season between May and October, so the material on the slopes is also transported due to the landslides and is also deposited in the Wailawa river. The material contained in the Wailawa river is analyzed to determine its character and if it is made into concrete it can contribute to resisting the landslides. The objectives of this study were: (1) to analyze the potential amount of material volume in the Wailawa river (2) to analyze the character of landslides that occur on the slopes of Mount Kohara (3) to analyze the physical and mechanical properties of the Wailawa river material (4) to analyze the compressive strength of the concrete cubes using the material of the Wailawa river. The methods used were field observations on the Wailawa river in Tawiri village, the test on characteristics of the material, and the test on the compressive strength of concrete in the structural laboratory, and literature studies. The results showed that the volume of material in the Wailawa river that could be utilized by the community was 1228.67m^3. Landslides at each location occurred at different times. Landslides in 2020 occurred with the total of landslide volume at location I amounting to 2,012 m^3 while at location II the total landslide volume was 11.93m^3. The material characteristic test showed that coarse aggregate can be used for making concrete, but the organic content contained in fine aggregate must be washed if it is to be used in normal concrete. The ability of concrete to withstand compression by a mixture of 1: 2: 3 had the highest strength of 151.62 kg/cm^2 or equivalent to 12.35 MPa and concrete with the lowest strength was shown by concrete with a mixture of 1: 7: 9 which had a minimum concrete strength of 10.12 kg/cm^2 or equivalent to 0.82 Mpa. The demonstrated ability of concrete indicated that the concrete can withstand the shear forces of the soil.

Keywords—*Landslide; Meterial; Compressive strength; Concrete mixture.*

I. Introduction

Some of the slopes of Mount Kohara (as the community is now called) are inhabited by the majority of Tawiri villagers, but the mountain can be categorized as a hill. The slopes of Mount Kohara are part of Mount Kadera [1] in Tawiri village, Ambon city often experiences partial landslides in every rainy season due to the disturbance of the slope stability, where the rainy season generally occurs between May and October with high rainfall in May, June, and July [2]. This resulted in material

casualties that occurred in 1984, while in 2011, 2013, and 2017 partial landslides took place again on several parts of the slopes.[3]

Effort to utilize slopes, one of which is the cutting of the foot of the slope, is one of the causes of landslides. The landslide that occurs is in the form of a mixture of grayish to yellow-red rock and soil which is dominated by fallen sand and forms a burrow causes some of the soil to hang off the slope head. The formation of *avur* on the slopes allows the closure of water flow due to falling trees during heavy rain which results in flash floods, causing material casualties experienced by residents who live on these slopes.[3]

The flow of water mixed with rock and soil material flows during the rainy season because of the landslides and due to erosion. The landslide material moves with the water when it rains and enters the Wailawa river, so some of the rock and sand also settles in the river which causes buildup or sedimentation.

The condition of the Wailawa River shows an irregular distribution of piles of material. The rock color is dominated by dark colors while the sand is more dominated by light colored grains. The position of the water flow often changes after the completion of the flood, or the rainy season causes the accumulation of material in a new location that will be overgrown with shrub grass after the next few days if the rainy season has passed. Therefore, the material in the Wailawa river in the village of Tawiri continues to accumulate and will reduce the water flow area which causes the overflow of flood water to come out of its path and crash into the settlements if not utilized.

The above conditions direct this research with the aim of: (1) analyzing the potential amount of material volume of the Wailawa river, (2) analyzing the character of landslides that occur on the slopes of Mount Kohara, (3) analyzing the physical and mechanical properties of the Wailawa river material, and (4) analyzing compressive strength of concrete cubes using the Wailawa river material.

II. Research Method

To find out the properties of the size of the Wailawa river, the study was carried out using the method of field observations: in the form of collecting data on watersheds. The measurement was made using a meter and a Garmin 78s GPSmap. Landslide slopes survey was also carried out in the same way, which was observing the landslide location.

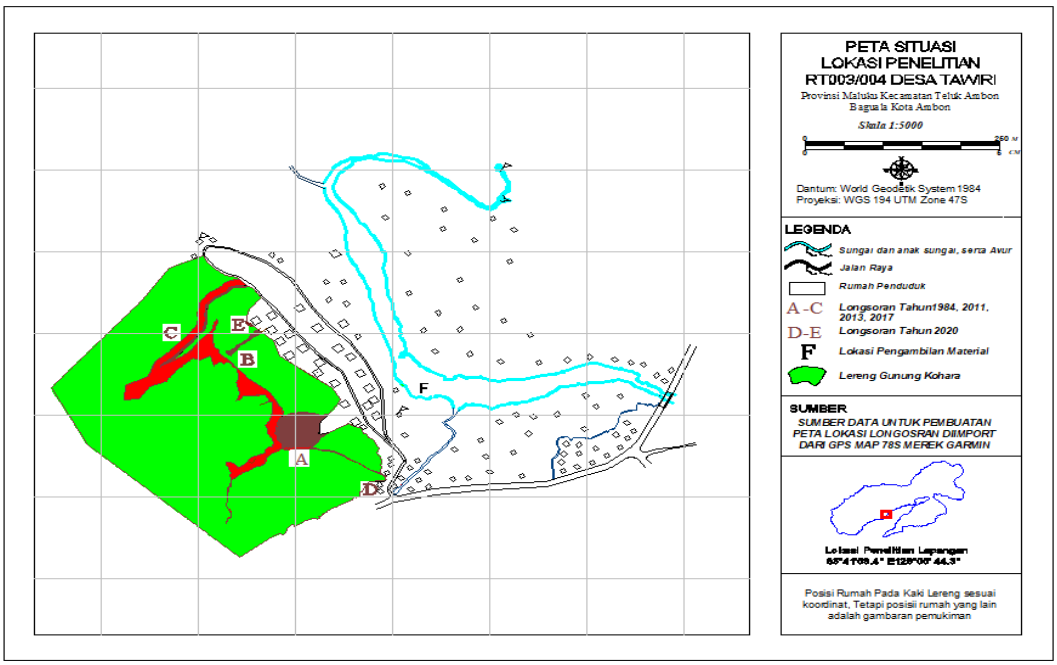

Figure 1. Study Site

Grading values and material characteristics (fine and coarse aggregates) were obtained by conducting tests at the structural laboratory of the Faculty of Engineering, Universitas Kristen

Indonesia Maluku. The aggregate gradient is the grain size distribution of the aggregate. If the aggregate grains have the same size (uniform), the pore volume will be large. Conversely, if the grain size varies, the pore volume will be small,[4] so in order to uniform the aggregate grains, a filter for sand was used as the final filter and the initial filter was of 40mm. Tests were carried out to determine the character values of the material include: Water content,[5] Absorption,[6] Volume Weight,[7] Relative density ,[7] and Organic Content. [6][8]

To determine the level of strength of concrete, a mixture of cement for 1 m^3 of 325 kg was used,[9] with an initial FAS of 0.55 for the type of concrete that enters the soil experiencing alternating wet and dry.[10] The mix design started with a 1: 2: 3 mixture with the weight of cement as the initial guideline, and 2 times more fine aggregate were added, followed by 3 times more coarse aggregate where the weight of the material was guided by the weight of the cement. The mixture 1: 3: 5 to 1: 7: 9 also had the same method so that it applied to the determination of coarse and fine aggregates, but the weight of cement did not change. However, materials (fine aggregate and coarse aggregate) were increasingly used.

A high level of structural strength requires a high compressive strength of concrete.[11] To determine the compressive strength of concrete, tests were carried out using compressive strength testing equipment at the Structural Laboratory of the Faculty of Engineering, Universitas Kristen Indonesia Maluku. Literature studies are used to analyze information about the existence of rivers and landslides due to patterns that are always displayed based on visual observations in the field, so that the conclusion is about the character of the two field conditions.

III. Result and Discussions

A. Characteristics of Wailawa River

Wailawa river can be categorized as [12] regim (flow regim) which is a river that tries or changes in seeking a balance between degradation and sediment aggression.[12] The morphometric characteristics of the watershed (DAS) that were analyzed were the area of the watershed,[13] where the measurement of the Wailawa river to determine the usable part of the material started from low on the river with a position of S03^o 42' 00.4" E128 ^{o} 05' 56.9". This position has a length of 6.7 meters from the Wailawa Bridge which is a bridge connecting the national road. The end of the measurement was stopped in position S03^o 41' 46.6" E128 ^{o} 05' 48.7"

The river that flows through the land (village) of Tawiri has the largest width of 59 m and the smallest width of 6 meters and the length surveyed and having a potential as a quary is 1200 m. Moving water does not completely fill the area in which it passes. Therefore, the volume owned by the Wailawa river using the calculation "take 2 meters height of aggregate deposits (gravel and sand)" followed the slope patterns that form along the river. The average width of 26.7 meters which is a collection of measurements to locations that have different widths and lengths of the survey location of 1200m get a volume of 1228.67m3 if the collection is carried out with human power capabilities.

B. Landslides in 2020

Landslides in general are the movement of soil, rock, and organic matter down a slope due to the influence of gravity which produces a new shape on the slope after movement. [14] The landslides occurred in 2020 were as many as 2 points along the slopes of Mount Kohara, Tawiri Village RT003/RW004. Landslides were started with heavy rain for more than one day, so that the soil fell from the slope which was open without protection on the ground in the form of grass growing on the ground. This condition is caused by slope cutting by the community. Falling continues every time it rains and causes holes in the slope body, eventually causing more landslides due to the hanging top of the slope. After the landslide, a new shape is formed, as in *waji* cut on the slope.

Figure 2. Landslides at the location behind Mr. Dani's house

Table 1. Landslide properties location 1

No	Description	P (m)	L (m)	Height/Thickness (m)
1	Length of the cut slope	55.1		
2	Slope	32^o		
3	Slope Height	1.5 - 6		
4	part of the slope that begins to slide			
5	Part I	3.1	1.2	0.3
6	Part II	3.2	1.4	0.2
7	Volume of Falling I	1.116	m^3	
8	Volume of Falling II	0.896	m^3	
9	Weight / Volume (γ_b) [3]	1.55	gr/cm^3	

There was pressure at location I caused by the soil in Part I of 1729.80 kg because the volume of the moving soil was 1.12 m^3 and the soil pressure in Part II was 1388.80 kg because the volume of the moving soil was 0.90 m^3.

Table 2. Landslide properties location 2

No	Description	P (m)	L (m)	Height/Thickness (m)
1	Length of the cut slope	20		
2	Slope	42^o		
3	Slope Height	1.2 - 5		
4	part of the slope that begins to slide			
5	Part I	4	3.5	0.7
6	Part II	6.3	2.25	0.15
7	Volume of Falling I	9.8	m^3	
8	Volume of Falling II	2.13	m^3	
9	Weight / Volume (γ_b) [3]	1.55	gr/cm^3	

At location 2, the ground pressure in Part I was 15190.00 kg due to the volume of the moving soil as much as 9.8 m^3, and the soil pressure in Part II was 3295.69 kg because the volume of the moving soil was 2.13 m3

C. Physical and Mechanical Properties of the Wailawa River Material

Aggregates are concrete mixture materials that are bonded together by cement adhesive. Based on the relative density, aggregate is divided into three groups, namely: (a) normal aggregate, which has a relative density between 2.5 to 2.7; (b) light aggregate, the relative density of which is less than 2.0; and (c) heavy aggregate, whose relative density is more than 2.8. [15] The results of tests carried out at the Structural Laboratory of the Faculty of Engineering obtained data on material characteristics (coarse gravel aggregate and gravel fine aggregate). Fine aggregate (sand) has the following characteristics: Water content 19.27%, Water absorption 20.13, Sand volume weight 1.19 gr/cm^3, apparent density 2.24, dry density 1.55, SSD density 1.86. The organic content that dissolves together in the sand after testing is red yellow where this organic content cannot be used with sand and must be washed if it is to be used for normal concrete. The coarse aggregate test (gravel) shows the results: water content 8.7%, water absorption 5.45, gravel volume weight 1.32 g/cm^3, bulk density: 2.24, SSD density 2.36, apparent density 2.55. The material contained in the Wailawa River is fine aggregate (sand) which indicates that sand can be classified into the light aggregate category, and coarse aggregate (gravel) indicates that this aggregate can be categorized as normal aggregate.

D. Compressive Strength of Concrete Cubes Using the Wailawa River Material

The compressive strength of concrete increases along with the age of the concrete, [16][17] but the compressive strength of concrete can also decrease along with the increase of aggregate/cement ratio.[18][19] The compressive strength characteristic of concrete is the typical compressive strength of concrete. This shows the class of the concrete itself.[20][21]

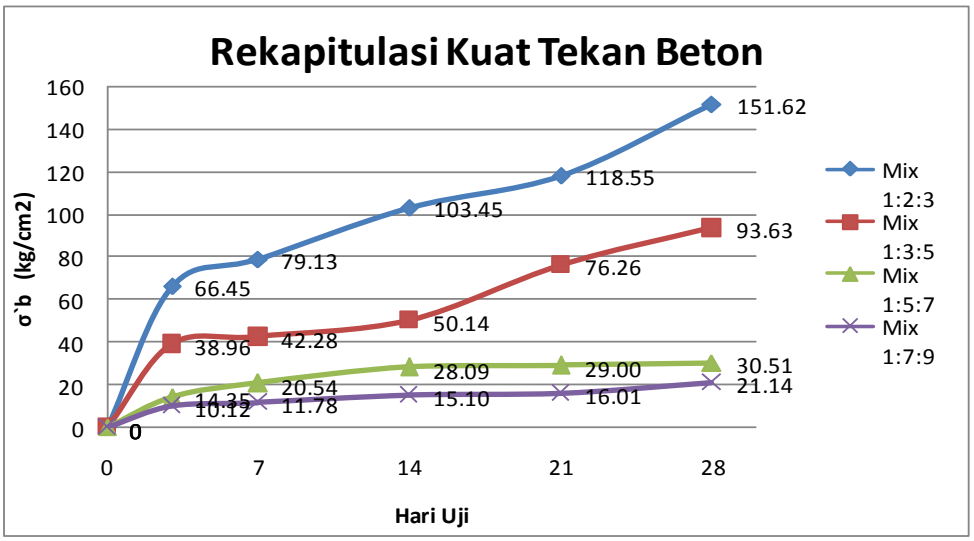

Figure 3. Compressive Strength of Concrete kg/cm^2

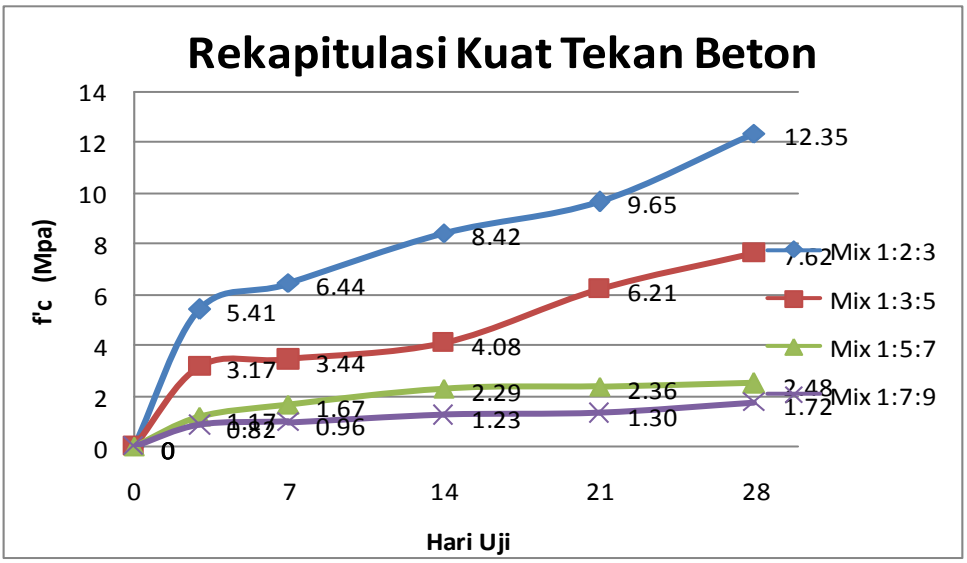

Figure 4. Compressive Strength of Concrete in the conversion to Mpa

The compressive strength test shows that the concrete cube with a mixture of 1: 2: 3 had strength when the concrete was three days old, which was 66.45 Kg/cm^2 or 5.41 Mpa and this mixture had strength when the concrete was twenty-eight days old with 151.62 Kg/cm^2 or amounting to 12.35 Mpa. The second position is occupied by concrete with a mixture of 1: 3: 5 where the strength of the concrete when it was three days old was 38.96 Kg/cm^2 or 3.17 Mpa. The strength of concrete with this mixture increased at the age of twenty-eight days, which was 93.63 Kg/cm^2 or 7.62 Mpa. The strength of the concrete which shows the compressive strength in the third position is concrete with a mixture of 1: 5: 7 where at the age of three days the strength of this concrete was 14.35 Kg/cm^2 or 1.17 Mpa, while at the age of twenty-eight days the strength of the concrete reached 30.51 Kg/cm^2 or 2.48 Mpa. The lowest withstand of compression is shown by a mixture of 1: 7: 9 with the strength of the concrete at three days could reach 10.12 Kg/cm^2 or 0.82 Mpa, while on the twenty-eight day it could reach 21.14 Kg/cm^2 or 1.72 Mpa.

The average weight volume of concrete owned by concrete with a mixture of 1: 2: 3, 1: 3: 5, 1: 5: 7, and 1: 7: 9 was 2096.99 Kg/cm^3, 2073.48 Kg /cm^3, 2011.46 Kg/cm^3, 1981.23 Kg/cm^3, respectively. The weight of the concrete shows that the ability of the concrete not to shift due to the horizontal pressure generated by the landslide is higher than the horizontal pressure of the soil, and this condition can be achieved if the concrete is made with a volume based on the thickness of the concrete walls of fifteen cm.

IV. Conclusion

The results showed that the volume of material that could be utilized by the community was 1228.67m3 and would increase if heavy equipment was used for collection. Landslides at each location occurred in different times with the volume of landslides at location I part 1 of 1,116 m^3 and part 2 of 0.896 m^3, while at location II landslide part 1 was 9.8 m3 and part 2 was 2.13 m^3. The material characteristic test shows that coarse aggregate can be used for making concrete, but the organic content contained in fine aggregate must be washed if it is to be used in normal concrete. The ability of concrete to withstand compression by a mixture of 1: 2: 3 had the highest strength, which was 151.62 kg/cm^2 or equivalent to 12.35 Mpa, and the concrete with the lowest strength was shown by the concrete with a mixture of 1: 7: 9 which had the minimum strength of concrete amounting to 10.12 kg/cm^2 or equivalent to 0.82 Mpa. The concrete weight for each cubic is greatly influenced by the amount of cement in the concrete. This can be seen from the test results that the highest ratio of weight to volume of concrete is shown by a mixture of 1: 2: 3 with an average result of 2096.99 kg/cm^3, and the ratio of the lowest weight volume of concrete is shown by a mixture of 1: 7: 9 with the

results the average yield was 1,981.23 kg/cm^3. The demonstrated ability of concrete indicates that the concrete can withstand the shear forces of the soil

Acknowledgement

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Measurement and modelingofparticulate matter (PM_{10})Concentration from on-road vehicles in Metro Cebu, Philippines

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ABSTRACT

The increasing traffic volume in Metro Cebu cumulatively affect human health associated to particulate matter pollution. This paper presented real time data of traffic volume and PM_{10} concentrationand policy measures simulation using STELLA^{TM}software. PM_{10}concentration from on-road vehicles were measured using Environmental Beta Attenuation Monitor (EBAM) inthree Metro Cebu cities, Lapu-Lapu City, Mandaue City and Cebu City. The vehicle fleet count was quantified using closed-circuit television (CCTV) records from the local city command centers. The 24-hour vehicle count and PM_{10}shows a strong correlation (r = 0.8586). Using Air Quality Index (AQI) breakpoints, Metro Cebu's PM_{10} is at good to fair level leaving no particular cautionary measures for the public though there are specific days where PM_{10} recorded a higher value. The four identified policy measures simulated using the System Dynamics Model(SDM) are purchase control, scrapping policy, traffic management, and vehicle emission mitigating measures. Hence, without policy implementation to decongest traffic in Metro Cebu, there will be an increasing demand of road expansion to accommodate traffic volume capacity.

Keywords—*system dynamics modeling; on-road vehicles; PM_{10}; EBAM; STELLA^{TM}; Metro Cebu*

I. INTRODUCTION

Urban traffic congestion associated with vehicle fleet expansion, over the years is affecting human health and urban air quality remarkably [1-2]. The increasing global record of particulate matter pollution in correlation with the traffic congestion and vehicle fleet expansion affect the environment and the life therein. These occurrences emphasized that despite the global particulate matter monitoring effort, a large amount of real time PM_{10} measurement from on-road vehicles are tough to quantify. In the past decade much studies focused on monitoring PM_{10} concentrations, the consideration was then shifted to coarse (1.0-2.5 microns), fine (0.1-2.5 microns), and ultrafine (0.1 microns) particulate matter because of their gradual effects to human health. However, by monitoring itself will not solve the problem and the widespread efforts remain indistinct.

In the framework of air quality problems, particulate matter is a notable type of air pollution in particle forms. Particulate matter is abbreviated as PM. It is a mixture of solid particles and liquid droplets contaminating the air mainly from natural and anthropogenic sources. Several natural sources originate from volcanic eruptions, dust storms, forest and grassland fires, and hurricanes. Anthropogenic sources are from coal burning, oil combustion from vehicles, burning fossil fuels in power plants, deforestation and tobacco smoke. Particulate matter comes in a wide range of sizes depending on the diameter of the particles. Particulate Matter (PM_{10}) has an aerodynamic diameter of ten microns. This size of the particles is dependent on meteorological conditions such as temperature, relative humidity, wind direction, and wind speed. PM_{10} released to the atmosphere is predominantly from fuel combustion of on-road vehicles [3]. Particulate matter pollution from on-road motor vehicle sources is not a new problem but because of its unceasing public health and environmental effects, the efforts to improve real time air quality monitoring and strategy implementation are reasonable. Developing countries' population growth, urbanization, and increasing number of vehicles drive air pollution [4].

On the other hand, Metropolitan Cebu or Metro Cebu has experienced a haze alert last September 18, 2019. The Indonesia haze reached Metro Cebu according to the Department of Environment and Natural Resources (DENR) through the Environmental Management Bureau - Region 7(EMB-7). The haze was from the forest fire Indonesia and enhanced by the Southwest monsoon with the air quality advisory posted as "above safe levels". The observed Particulate Matter ($PM_{2.5}$) reached 56 $\mu g/m^3$ above the safe levels of 50 $\mu g/m^3$[5]. The haze is a conglomeration of natural and anthropogenic activities that resulted to an increase level of particulate matter. Metro Cebu is the primary urban settlement of the Central Visayas Region (Region VII) composed of seven cities; Cebu, Mandaue, Lapu-Lapu, Talisay, Naga, Carcar and Danao, and six (6) municipalities; San Fernando, Minglanilla, Cordova, Consolacion, Lilo-an, and Compostela [6]. Metro Cebu is a home of 2,849,213 people as of August 1,2015 [7].

Emission inventories for on-road vehicles require the number of vehicles, vehicle fleet, vehicle age, number of vehicles meeting the emission control strategies implemented, annual Vehicle Kilometer Travelled (VKT), vehicle speed, meteorological conditions, fuel characterization, and consumption information. These parameters for emission inventory are difficult to quantify for on-road vehicles. For baseline information, the total number of on-road vehicle fleet is the minimum requirement to start vehicle emission assessment. The system dynamics of on-road vehicles generally from the total number of vehicle fleet inflow and scrapping outflow. The interaction of vehicle inflow and outflow sustain balance in an ideal dynamic system. A vehicle fleet size will not grow exponentially for an indefinite period because it can reach to a maximum size limit caused by one of the deficiencies of one or more identified variables [8]. Local factors such as travel activity, traffic patterns, meteorological conditions, spatial and temporal combining its emission control programs have significant effects in the particulate matter dynamic system.

The study is conducted to establish baseline data of Metro Cebu's real time PM_{10} concentration and traffic volume measurement from its chartered cities. The measured PM_{10} concentration and real time traffic volume can be a useful data in evaluating local and national air quality standard, vehicle emission, mitigating measures, and future policies. Policy implementations were argued due to lack of reliable data that authenticates the policies. While it is also evident that PM_{10} concentration from on-road vehicles can affect human health and the environment by means of unrestricted, uncontrolled, and unquantified measures. The study findings can be maximized in mitigating Metro Cebu's particulate matter pollution from on-road vehicle fleet. The study output can be used as a reference for environmental and transportation agencies for policy implementation. The study presented helpful scenarios for local government to support new technologies for sustainable environmental impact in the coming years in Metro Cebu. It specifies number of useful scenarios through forecasting and analyzing the system dynamics of real time traffic volume.

II. Field Measurementsand Social Survey

A. Study Site Description

The study sites are situated in the three chartered cities of Metro Cebu, Philippines. Metropolitan or Metro Cebu is in the Cebu province of the Central Visayas Region, composed of seven (7) cities and six (6) municipalities. The seven cities are Cebu, Mandaue, Lapu-Lapu, Talisay, Naga, Carcar and Danao. The six (6) municipalities are composed of San Fernando, Minglanilla, Cordova, Consolacion, Lilo-an, and Compostela (Fig. 1). Metro Cebu has a total population of 2,849,213 as of August 1,2015 [7]. The Philippine Statistics Authority (PSA) is the implementing agency for primary data collection and conducting censuses particularly population sector.

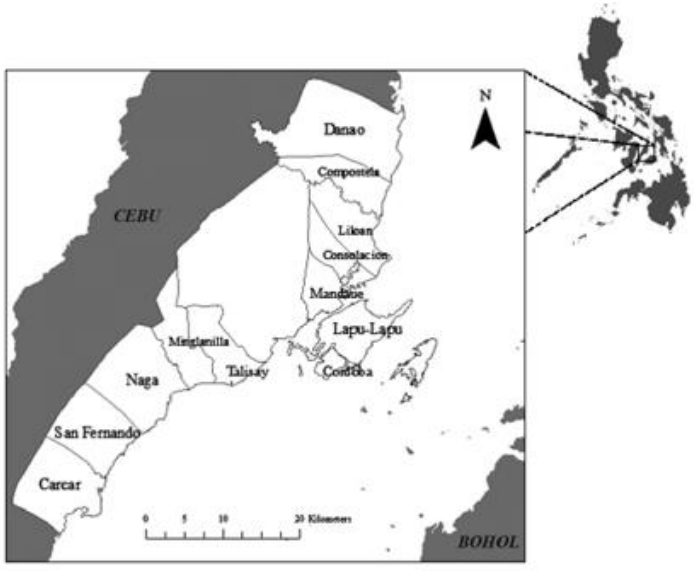


Fig. 1. Location map of Metro Cebu, Philippines.

B. Sampling Sites for PM_{10}

The three (3) sampling sites were positioned in major junctions and driving routes with moderate to high traffic volume daily. Fig. 2 indicates the location of the sampling sites where PM_{10} concentration sampling and vehicle fleet counting were conducted. Sampling site 1 is located at Lapu-lapu City's one of its major junctions where traffic bottle neck usually occurs from and to the Osmeña bridge. Sampling site 2 in is located near the N. Bacalso national road connecting from Cebu City to the South area of Cebu and few crossroads of the nearby barangays. Sampling site 3 is located on one of the jammed junctions in Mandaue City, A. Soriano Street where vehicles like trucks, trailers, SUVs, and personal cars mostly travel.

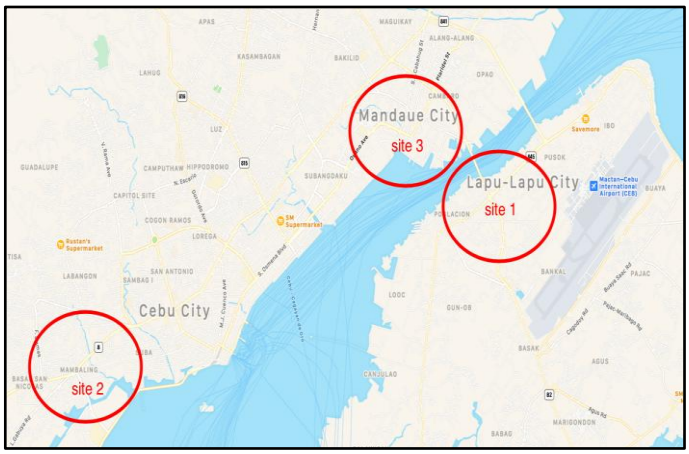


Fig. 2. Location of the sampling sites.

The 24-hour measurement cycle for PM_{10} from 12AM to 11PM in the three sampling sites were taken by using an EBAM. At the same sampling period, a 24-hour vehicle fleet counting for sampling site 3 in Mandaue City was observed to fully examine the traffic volume daily. Furthermore, a total of 2 hours vehicle fleet counting for sampling site 1 in Lapu-lapu City was captured to get an hourly snapshot count; one hour counting from 6AM to 7AM and 5PM to 6PM. The chosen time of hourly snapshot vehicle fleet counting which is six to seven in the morning and five to six in the evening, were in reference to the study of traffic patterns. As reported by Ganveer and Tiwari [9] in their study, several

vehicular accidents recorded in a day are mainly happened during six in the morning to six in the evening. Vehicular accidents slow down traffic flows. This study is limited to CCTV vehicle fleet counting. There were no vehicular accidents happened during the vehicle counting period in the specified sampling sites, and no other related factors related to vehicular accidents were observed.

C. Measurement of On-road Vehicle Fleet

This study focused on field measurement for real time vehicle fleet counting conducted in Lapu-lapu City and Mandaue City instead of using registered vehicles record in the Land Transportation Office (LTO), since some vehicles aren't running in the same roads and at the same time where they were registered. This study also involved Closed-Circuit Television (CCTV) records because CCTV captures real time data, all types of vehicles, and can be stored and reviewed for further validation. The real time CCTV videos were extracted from the Closed-Circuit Television (CCTV) monitoring from Lapu-lapu City and Mandaue City command centers. The CCTV copies were retrieved from the command centers with proper permission and coordination of the purpose stated in this study.

The 24-hour vehicle fleet counting took place at sampling site 3 located in Mandaue City Sports and Complex, UN Avenue, Mandaue City. The two-hour daily snapshot vehicle fleet counting for sampling site 1 is at the major junction of Basak-Marigondon Rd. and M.L Quezon National Highway, Lapu-lapu City near Menzi Complex Corner. Sampling site 1 hourly vehicle fleet count in the morning (6:00 AM - 7:00 AM), and an hour vehicle count in the evening (5:00 PM - 6:00 PM). For sampling site 2 located in Cebu City command center, real time vehicle fleet count was not available for the sampling dates due to CCTV system breakdown.

This study grouped on-road vehicle fleet into diesel fueled and gas fueled vehicles. According to the LTO region 7 record in 2015, the two widely used motor vehicles are gasoline and diesel fueled. The study quantified vehicle type through manual description by listing down in the vehicle counting sheet the number of motor vehicles as seen on CCTV. The approach used to guide the quantification of the on-road vehicle count follows that of USEIA [10]. The diesel fueled vehicle fleet in this study predetermined grouped into SUV, bus, truck, and trailer. The gas fueled vehicle fleet was also clustered into car, jeepney, and motorcycle or tricycle. It was distinctly evaluated by USEIA [11] that most consumers of gasoline fuels are cars, light trucks, and motorcycles.

Travel activities served as vehicle inflows and vehicle outflows. Vehicle inflow is from Lapu-lapu City to Mandaue City to Cebu City routes. Vehicle outflow is from Cebu City to Mandaue City to Lapu-lapu City. The consistency of the traffic flow was not dependent on the driving routes. The inflow from Lapu-lapu City (site 1) not necessarily goes through the same inflow in Mandaue City (site 3). And not all inflows in Mandaue City were also coming from Lapu-lapu City. On-road real time vehicle counting varies every time on different places, local factors, and conditions. This study considered the real time vehicle count on the same date of the PM_{10} sampling to observe its correlation. For sampling site 1, vehicle inflow from Lapu-lapu City to Mandaue City (Fig.3a), while vehicle outflow from Mandaue City to Lapu-lapu City. All vehicle inflow and outflow passed through Osmeña bridge as the bottle neck of the traffic linkage from Lapu-lapu City and Mandaue City. For sampling site 3, Mandaue City vehicle inflows were from A. Soriano Street of Mandaue City to Cebu City, while vehicle outflows were from Cebu City to A. Soriano Street main highway that goes through the Northern part of Cebu province, Lapu-lapu City, or local barangays within the area (Fig.3b). Vehicles that travel to sampling site 1 in Lapu-lapu City were consistently considered as outflow of the vehicle traffic count.

(a) (b)

Fig. 3. Actual CCTV vehicle inflow and outflow travel activity at (a) Osmeña bridge front at Lapu-lapu City and (b) A. Soriano street near Mandaue City sports and complex, Mandaue City

D. Social Survey

This study adapted the Slovin's random sampling technique formula to estimate the appropriate sampling size in Metro Cebu. Slovin's formula used in related study found in article DOI: 10.21474/IJAR01/6935 [12]. The Slovin's formula,

$$n = \frac{N}{(1 + Ne^2)} \tag{1}$$

where, n= no. of samples; N= total population; e= margin of error

Substituting the total population (N) of 2,849,213 and margin of error (e) 10% , the sample size needed is 100. One hundred individuals were the minimum sample size to estimate the true population proportion with the margin of error (10%) and confidence level of 95%.

III. System Dynamics Modeling

This study used STELLA™ software to develop and simplify complex systems such as the dynamic of real time on-road scenarios. The System Dynamics Model (SDM) framework of this study has three essential sectors namely, population and health, vehicle fleet and traffic, and PM_{10} concentration (Fig. 4). Each sector contributes to one another. The framework was specifically designed for on-road vehicles and PM_{10} concentration system dynamic modeling. One major feedback cycle started from population growth inflow to a population stock. The *population* was subject to an increase or decrease of its quantity by the population growth and mortality. These individuals in the population stock were the same individuals who has the probability and capacity to purchase a vehicle. The purchase rate was initially set to 3% of the total population of 3,000,000 (whole number estimate for Metro Cebu from the previous 2015 census of 2,849,213). *Purchase* served as inflow to the vehicle fleet conveyor. The *vehicle fleet* conveyor has a sub-model that identifies the maturity stages of the total vehicle fleet. The current value of the conveyor is set to 30,000 vehicles in reference to ADT values plus the incoming purchases. These vehicle quantity goes through maturity stages through its external input of the Vehicle Kilometer Travelled (VKT). The total vehicle fleet was subject to scrap after five - year maturity stages. Total vehicle fleet contributes to the on-road traffic volume inflow conveyor. The *traffic volume* conveyor was initially set to 18,000 based from actual vehicle count in Mandaue City. Mandaue City has an average of 18,000 average daily traffic. As vehicles gets in the conveyor, it remained for a certain period due to some traffic delays before exiting. Traffic delays was already considered in the vehicle transit time. The outflow of the traffic volume contributes to the traffic congestion then to the vehicle emission conveyor. *Vehicle emission* conveyor increase or decrease gradually because of the quantity fed by the traffic volume. Primary pollutants were mixed or interacted with other pollutant due

to meteorological condition factors and other anthropogenic activities in the surrounding area, it was fed into the secondary pollutant inflow then to the PM_{10} conveyor. *PM_{10}*as a conveyor helped processed the short-term and long-term effects added to the atmosphere and health effects to the population. Health effects not just mainly coming from PM_{10} exposure but even during traffic congestion where traffic stress already felt, as per social survey 23% get stressed and another 23% get frustrated and stressed at the same time. Stress is not directly related to PM_{10}. However, traffic stress can affect human health. Human health was affected by particulate matter pollution. Human health converter served as an external input to the increase or decrease of the population growth.

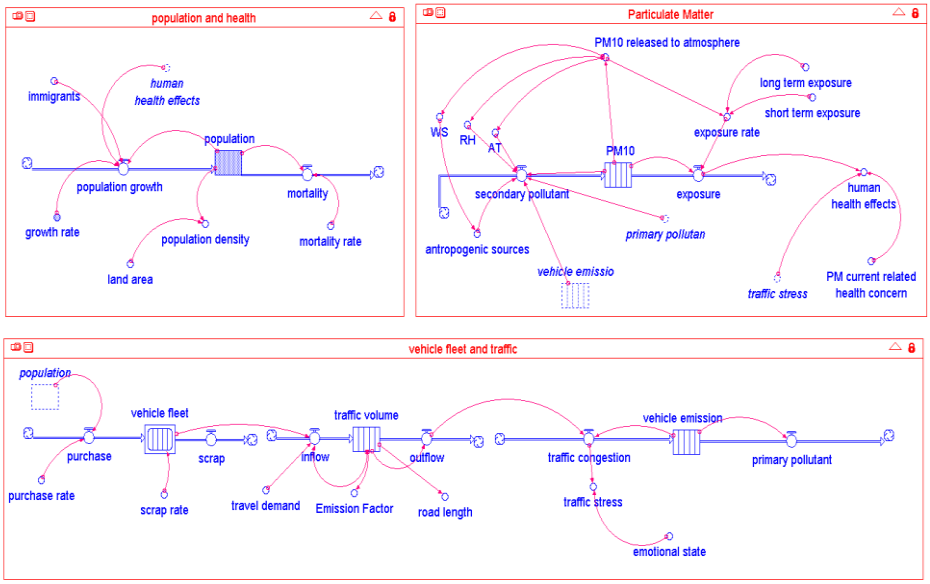


Fig. 4. System Dynamic Model (SDM) framework using STELLA™ software for real time on-road vehicle fleet and PM_{10} concentration modeling.

The PM_{10} concentration conveyor was initially conditioned to 150μg/m^3 in reference from the National Ambient Air Quality Guideline Values (NAAQGV) of PM_{10} concentration. The 150μg/m^3 considered moderately polluted where health impact is felt like breathing discomfort for individuals with respiratory related concern. At this concentration level, the public is not yet likely to be affected. An increase of 1μg/m^3 is already considered a poor air quality. The SDM also simulated scenarios for 120μg/m^3 annual averaging time.

A defined course of action in the model was interpolated to distinguish difference from initial conditions. Policy measures introduced in the model determines present and future decisions with its acceptable procedures and realistic values. The purchase control influenced the purchase rate of vehicles, scrapping policy to the number of vehicle fleet, traffic management to organize the average traffic volume, and mitigating measures to be implemented to minimize vehicle emission. An addition of 50% implementation of the four policy measures such as purchase control, scrapping policy, traffic management, and mitigating measures converters resulted to a decreasing behavior of the variables (Fig. 5).

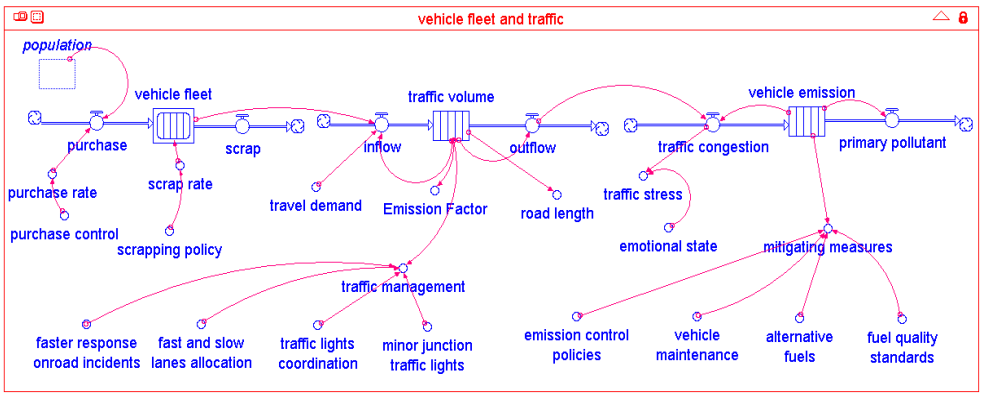
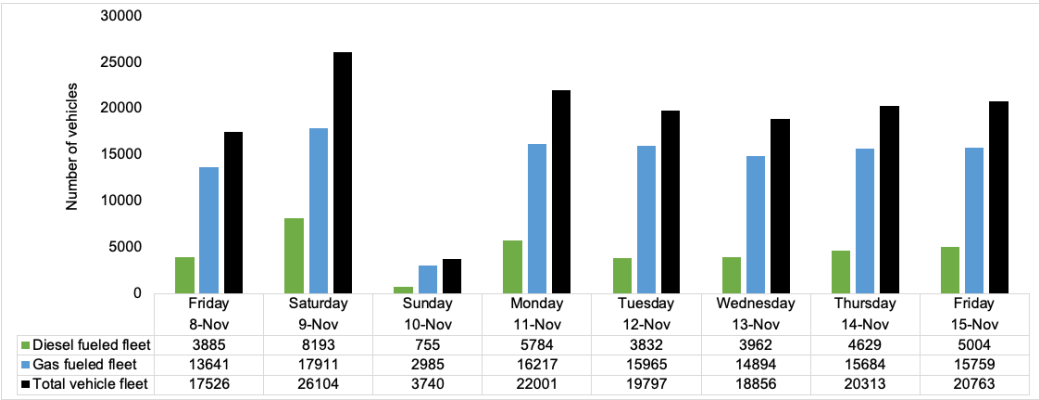


Fig. 5. SDM framework with the four interpolated policy measures; purchase control, scrapping policy, traffic management, and mitigating measures.

IV. Results and Discussion

A. Daily Traffic Volume

After thorough observation and vehicle fleet counting, Fig. 6 presents the total 24-hour counting cycle from November 8 to 15, 2019. The vehicle fleet count was classified by vehicle fuel type; diesel fueled fleet and gas fueled fleet. For the total duration of the vehicle counting period, the highest total vehicle fleet was observed on November 9, 2019 on Saturday for 26,104 number of vehicles running on road. The total vehicle fleet recorded on Saturday was 26,104 number of vehicles, a close record to the estimated Average Daily Traffic (ADT) of 30,000. For the sampling period, Mandaue City has an average of 18,000 on-road motor vehicles daily for the specific major junction in Mandaue City Sports and Complex, UN Avenue, Mandaue City. The lowest number of on-road vehicle fleet was recorded on November 10,2019 on Sunday at 3,740. The total vehicle fleet was 149,100 for the vehicle counting duration. Diesel fueled accounts 36,044 and gas fueled 113,056 number of vehicles. Gas fueled vehicle fleet consistently showed higher count from November 8 to 15, 2019. Either gas or diesel fueled vehicle fleet, it appeared to have higher count on Saturday and lowest count on Sunday.



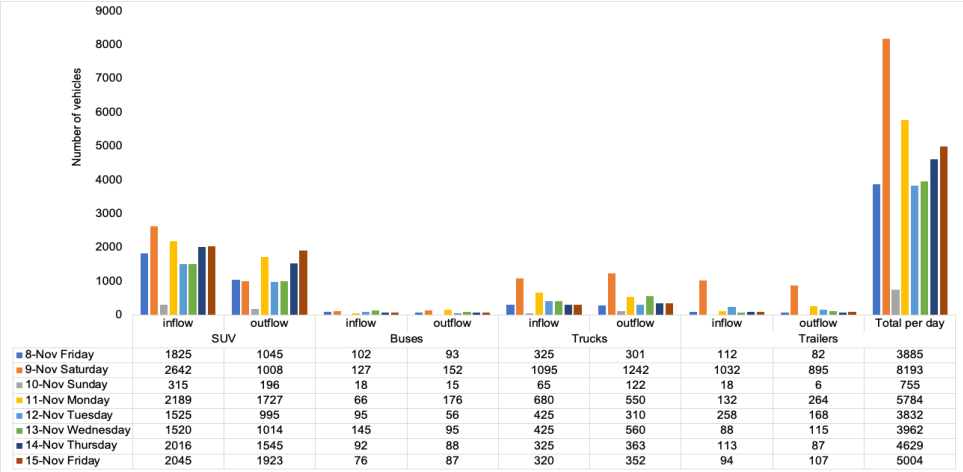
	Friday 8-Nov	Saturday 9-Nov	Sunday 10-Nov	Monday 11-Nov	Tuesday 12-Nov	Wednesday 13-Nov	Thursday 14-Nov	Friday 15-Nov
Diesel fueled fleet	3885	8193	755	5784	3832	3962	4629	5004
Gas fueled fleet	13641	17911	2985	16217	15965	14894	15684	15759
Total vehicle fleet	17526	26104	3740	22001	19797	18856	20313	20763

Fig. 6. A 24-hour comparison for diesel and gas fueled vehicle fleet in Mandaue City Sports and Complex, UN Avenue, Mandaue City from November 8 to 15, 2019

Gas fueled vehicle fleet has the higher total number of vehicles compared to diesel fueled fleet. The strong number of the gas fueled vehicle fleet was from motorcycles and tricycles or MC/TC. MC/TC total inflow for eight days was 30, 372 and 28,812 for outflow, a total of 59,184 running on road for the duration. This account the highest among the vehicle fleet category. The SUV's was the second highest vehicle fleet count with the inflow of 14,077 and outflow of 9,453, total of 23,530. The lowest

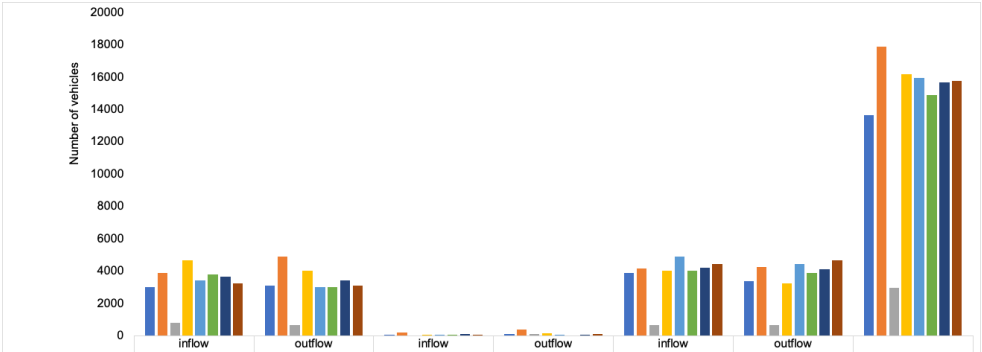
count for gas fueled vehicle category were from jeepneys with the inflow of 794 and outflow of 1,115, total of 1,909. Bus contributes the lowest count for the diesel vehicle category that accounts the inflow of 721 and 702 outflow, total of 1,423.

The breakdown of the vehicle counts per day and per fuel used is presented in Fig. 7and 8. SUV appeared the highest trend count for diesel fueled and MC/TC displayed the highest trend count for gas fueled vehicle fleet. SUV highest trend recorded was on November 9 and 15, 2019 for 2,642 (inflow) and 1,923 (outflow) respectively. MC/TC has 4,895 (inflow) on November 12 and 4,695 (outflow) on November 15, 2019.



	SUV		Buses		Trucks		Trailers		
	inflow	outflow	inflow	outflow	inflow	outflow	inflow	outflow	Total per day
8-Nov Friday	1825	1045	102	93	325	301	112	82	3885
9-Nov Saturday	2642	1008	127	152	1095	1242	1032	895	8193
10-Nov Sunday	315	196	18	15	65	122	18	6	755
11-Nov Monday	2189	1727	66	176	680	550	132	264	5784
12-Nov Tuesday	1525	995	95	56	425	310	258	168	3832
13-Nov Wednesday	1520	1014	145	95	425	560	88	115	3962
14-Nov Thursday	2016	1545	92	88	325	363	113	87	4629
15-Nov Friday	2045	1923	76	87	320	352	94	107	5004

Fig. 7. A real time diesel fueled vehicle fleet count from November 8 to 15, 2019 in Mandaue City Sports and Complex, UN Avenue, Mandaue City



	cars		jeepney		MC/TC		Total
	inflow	outflow	inflow	outflow	inflow	outflow	
8-Nov Friday	3025	3112	95	102	3895	3412	13641
9-Nov Saturday	3918	4920	230	405	4152	4286	17911
10-Nov Sunday	807	666	25	107	695	685	2985
11-Nov Monday	4690	4015	66	175	4015	3256	16217
12-Nov Tuesday	3425	3025	85	76	4895	4459	15965
13-Nov Wednesday	3825	3012	75	43	4045	3894	14894
14-Nov Thursday	3672	3455	120	89	4223	4125	15684
15-Nov Friday	3274	3122	98	118	4452	4695	15759

Fig. 8. A real time gasoline fueled vehicle fleet count from November 8 to 15, 2019 in Mandaue CitySports and Complex, UN Avenue, Mandaue City

B. PM10 and Human Health

The PM_{10} concentration averaging time (μg/m^3, 24-hr) measured in the three sampling areas of the chartered cities in Metro Cebu showed from good and fair AQI breakpoints with no cautionary statements for the public (Table 1).

Table 1. PM_{10} Averaging Time (µg/m^3, 24hr) for Lapu-lapu City, Cebu City, and Mandaue City from the selected duration of September 18 to November 30, 2019.

PM_{10} concentration averaging time (µg/m^3, 24hr)														
Date (2019)	18-Sep	19-Sep	20-Sep	21-Sep	22-Sep	23-Sep	24-Sep	25-Sep	26-Sep	27-Sep	28-Sep	29-Sep	30-Sep	1-Oct
Lapu-lapu City	69	64	49	61	68	82	61	58	56	57	65	49	53	57
Date (2019)	17-Oct	18-Oct	19-Oct	20-Oct	21-Oct	22-Oct	23-Oct	24-Oct	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct
Cebu City	46	49	47	47	40	34	36	39	31	31	23	29	38	37
Date (2019)	1-Nov	2-Nov	3-Nov	4-Nov	5-Nov	6-Nov	7-Nov	8-Nov	9-Nov	10-Nov	11-Nov	12-Nov	13-Nov	14-Nov
Mandaue City	50	40	24	43	48	45	47	77	112	50	94	100	84	95
	15-Nov	16-Nov	17-Nov	18-Nov	19-Nov	20-Nov	21-Nov	22-Nov	23-Nov	24-Nov	25-Nov	26-Nov	27-Nov	28-Nov
	70	73	53	84	93	99	96	89	49	50	49	74	86	76
	29-Nov	30-Nov												
	57	52												

Legend:

Good	Fair	Unhealthy for sensitive groups	Very Unhealthy	Acutely Unhealthy	Emergency

C. 24-hour PM10 and On-road Vehicle Fleet Correlation

This study used the Pearson Product-Moment Correlation Coefficient (PPMCC) (Level 3 Advanced Subsidiary GCE, 2014). Pearson r correlation used to measure the degree of relationship between the two linear variables. A 24-hour vehicle counting cycle was conducted in at Mandaue City Sports and Complex, UN Avenue, Mandaue City from November 8 (Friday) to November 15 (Friday), 2019. The average PM_{10} concentration data set in correlation to the vehicle count was equated at the same date of the vehicle sampling duration. Fig. 9shows a strong positive relationship of the total vehicle fleet and PM_{10} concentration at a correlation coefficient of r = 0.8587. As the number of PM_{10} concentration increases, the total vehicle fleet also increases. The extreme value causing the positive relationship was coming from the data set on November 10, 2019, Sunday, when the total vehicle fleet count and PM_{10} concentration were notably lower compared to some other days of the sampling duration.

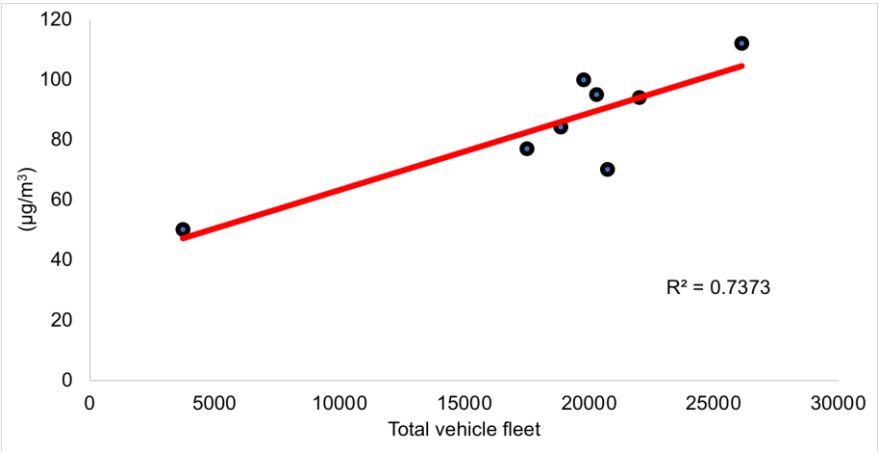
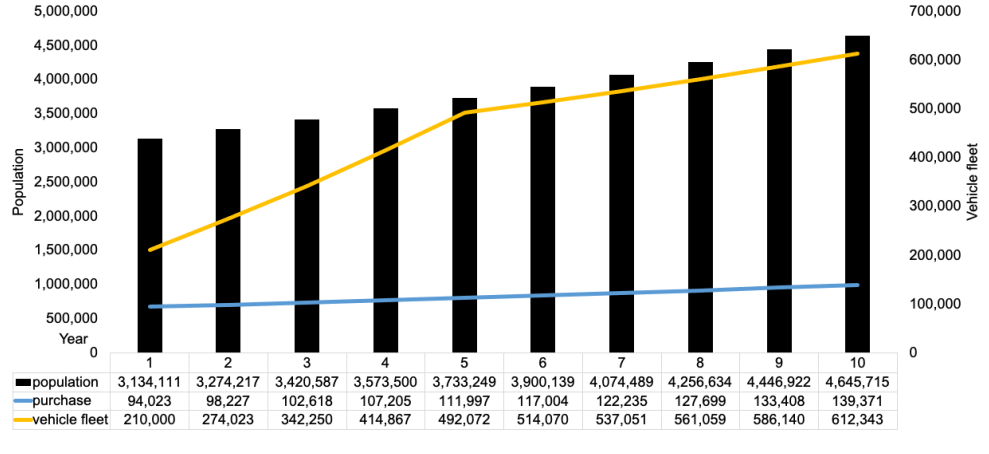


Fig. 9. The 24-hour PM_{10} concentration and total vehicle fleetcorrelation

D. SDM Simulation Results

The initial conditions were set as follows; PM_{10} at 150μg/m^3, population of 3,000,000, and purchase rate of 3%. The 3% of the total population is equal to 90,000 estimated individuals who purchased vehicles. Vehicle fleet initial conditions in the vehicle fleet sub-model was estimated Average Daily Traffic (ADT) of 30,000 vehicles. In the sub-model, it is consistently distributed to 5 cohorts which resulted to 150,000 vehicles for the first simulation period. Traffic volume initial condition is at estimated 18,000 daily average based from the real time traffic volume in Mandaue City. Scrapped vehicles on the first simulation resulted to 30,000 on its first year and on the following 5 years. Starting on the fifth year, the 90,000 purchased vehicles on the first simulation run will be scrapped. The model is conditioned to every five years scrapping of vehicles. Human health effects simulated result value came from traffic stress, Particulate Matter (PM) health related concern, and direct exposure from PM_{10} concentration. The value of human health effects resulted to 5% or 150,000 (3,000,000 * .05) individuals particularly residing within the radius in Metro Cebu. The SDM simulated statistical results for Metro Cebu's population, vehicle purchase, and vehicle fleet for ten years projection is shown in Fig. 10. The three variables point out an increasing direct variation from the start of the simulation. Largely, the number of vehicles in the vehicle fleet are from the growing population who has the capacity to purchase a vehicle.



Year	1	2	3	4	5	6	7	8	9	10
population	3,134,111	3,274,217	3,420,587	3,573,500	3,733,249	3,900,139	4,074,489	4,256,634	4,446,922	4,645,715
purchase	94,023	98,227	102,618	107,205	111,997	117,004	122,235	127,699	133,408	139,371
vehicle fleet	210,000	274,023	342,250	414,867	492,072	514,070	537,051	561,059	586,140	612,343

Fig. 10. SDM simulated results for Metro Cebu's population, vehicle purchase, and vehicle fleet for ten (10) years projection.

Model simulation of PM_{10} concentration and traffic volume is displayed in Fig. 11. After ten years, from the initial condition values, the population reached 4,645,715. These 4,645,715 individuals residing in Metro Cebu, a maximum of 139,371 can purchase a vehicle which will be adequate for the total vehicle fleet of 612,343, traffic volume of 18,035, with a focusing health effects to the total population.

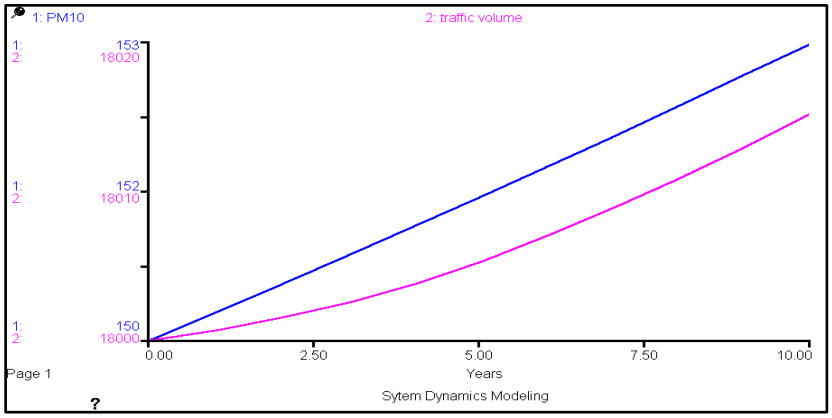


Fig. 11. Model simulation of PM_{10} concentration and traffic volume

E. SDM Scenario Analysis and Policy Implementations

The vehicle fleet in Metro Cebu grows exponentially over time without purchase control. The vehicle scrapping will not compensate the goal to sustain the average daily traffic because scrapping also means buying a new vehicle. Setting the purchase rate to 3% has restricted number of vehicle fleet to be purchased and eventually sustaining the on road average daily traffic volume. Scrap rate of 1% or higher every year will help lessen number of total vehicle fleet and traffic volume. The four identified policy measures interpolated in the SDM framework helped determine the effect of the implementation policy. The focusing effects of the policy measures namely purchase control, scrapping policy, traffic management, and mitigating measures converters gave the total predetermined simulation results. In the survey, eighteen percent (18%) of Metro Cebu's population will purchase a vehicle in the next five years. The SDM forecasted that after five years, Metro Cebu's population will reach, 3,733,249. The eighteen percent (18%) of 3,733,249 is 671,984, however, as the model simulated, the allowable total vehicle fleet is 492,072 to sustain on-road traffic volume. The real time vehicle fleet count recorded a total of 186,981 vehicles on-road for the counting duration in 2019, giving an average traffic volume of 18,000 daily. Thus, without proper mitigation and policy implementation to decongest traffic in Metro Cebu, there will be an increasing demand of road expansion to accommodate traffic volume capacity. The demand for space becomes greater than what is available leading to a more complex effects for transport and other sectors in Metro Cebu.

The SDM modeled direct health effects of PM_{10} concentration of annual average of 150μg/m^3 and 120μg/m^3 ranges from five to six percent of the total population in Metro Cebu depending on the level of exposure. At 120μg/m^3, 23% of the total population is estimated to be exposed of PM_{10} concentration giving a higher direct health effect of 6%. At 150μg/m^3, the total estimated population to be exposed is at 19% yielding 5% direct health effects.

V. Conclusion

The 24-hour measurement cycle between PM_{10} and total vehicle fleet observed in Mandaue City shows a strong correlation (r = 0.8587). The strong predictor of the high correlation was from the gas fueled vehicle fleet which dominantly comprises of motorcycles and diesel fueled vehicle fleet which is dominated by SUVs. The vehicle fleet temporal variations are observed to have high number of on-road vehicles from Mondays to Saturdays and low number on Sundays.

The PM_{10} concentrations obtained in the study were evaluated using the AQI breakpoints. The PM_{10} concentrations in the three sampling locations conducted in Lapu-lapu City, Cebu City, and Mandaue City detected as good to fair breakpoints level leaving no cautionary measures for the public. However, sudden spikes of PM_{10} concentrations were observed in specific days and time that exceed healthy

breakpoints. Thus, a real time monitoring of PM_{10} concentration suitably necessary for Metro Cebu's continuous air pollution monitoring.

The SDM shows that vehicle fleet in Metro Cebu grows exponentially over time without purchase control. The sustainable purchase rate is at 3% or below yearly and a scrap rate of 1% or higher. The four identified policy measures such as purchase control, scrapping policy, traffic management, and vehicle emission mitigating measures converters interpolated in the SDM framework helped determine the effect of the implementation policy. As evaluated in the survey, eighteen percent (18%) of Metro Cebu's population will purchase a vehicle in the next five years. Hence, without policy implementation to decongest traffic in Metro Cebu, it may result to an increasing demand of road expansion to accommodate traffic volume capacity.

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Potential benefits of Waste-to-Energy (WTE) for Turkey

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ABSTRACT

The only proven alternative of landfilling for the management of the post-recycling waste, that means the waste with no value in the market or recovery potential, is thermal treatment for the recovery of energy (waste-to-energy or WTE). The benefits of WTE over landfilling are mainly associated with the complete destruction of pathogens, the volume reduction of the municipal solid waste (MSW) by 90%, the production of about 0.5 MWh of electricity and more than 0.6 MWh of district heating per ton of MSW combusted; the savings of about 0.5 to 1 ton of Greenhouse Gases emissions per ton of MSW, and the preservation of about 1 sq. meter of land for every 10 tons of MSW. However, there is continuing opposition to WTE based on the early history of incineration, and the concern that these technologies will emit harmful pathogens to public health; but, also, due to the high capital costs as compared to landfilling. On top, capacity building is one of the major issues for the deployment of such technologies, especially for countries with no prior expertise. The aim of this study is to provide a snapshot of the current status of waste management in the world, provide evidence on the role of WTE in sustainable waste management, and assess the benefits of such technologies for the case of Turkey. The main finding from the global assessment was that developed nations took several decades to reach their present state of development and achievement in sustainable waste management. On the other hand, developing nations can use the Chinese example and accelerate the phasing out of landfilling or the improper dumping by the massive application of WTE technology. Specifically for the case of Turkey, a nation with high energy dependency on other countries, and with ~70% of MSW landfilled; with the assumption that 50% of the MSW produced in the country will be processed for the production of energy, WTE deployment will be associated with the savings of ~$122 MM per year, by the substitution of natural gas. Also, WTE can contribute up to 2% to the electricity demand of the country, and can lead to the savings of ~ 1.5 million tons of $CO_{2\text{-eq}}$ and ~1.6 million m^2 of land; besides, the aesthetic superiority as compared to landfilling.

Keywords—*Sustainable waste management; Waste-to-Energy; Turkey; energy recovery.*

I. INTRODUCTION

An effective waste management is inevitable in order to live in a sustainable, healthy and enjoyable environment. There are several techniques for managing municipal solid waste (MSW) such as recycling, composting, waste-to-energy, landfilling and dumping. Waste-to-energy (WTE) is used for non-landfilling and non-recycling materials. Although recycling is a more desired method among all waste management techniques [1], some materials can not be recycled. If a material can not be recycled, one of the best options is WTE according to the waste management hierarchy [1]. WTE is

an effective method for waste management in which energy is recovered from waste. Themelis et. al (2013) states that the reaction of combustion of organic compounds is highly calorific and the theoretical heat of reaction is estimated as 18.5 MJ/kg [2].

Turkey is one of the developing countries with an 11% increase of population between 2008 and 2018 [3] and thus, its energy needs increase steadily, in 2018, Turkey's primary energy consumption was 153.5 million toe [4].

Figure 1 shows that oil, coal and natural gas are the dominant primary energy sources in Turkey with 86% of all energy consumption [4]. Furthermore, 68% of the electricity generation comes from coal and natural gas in the country [4]. Therefore, it can be said that primary energy usage and electricity production mostly dependent on the fossil fuels in Turkey.

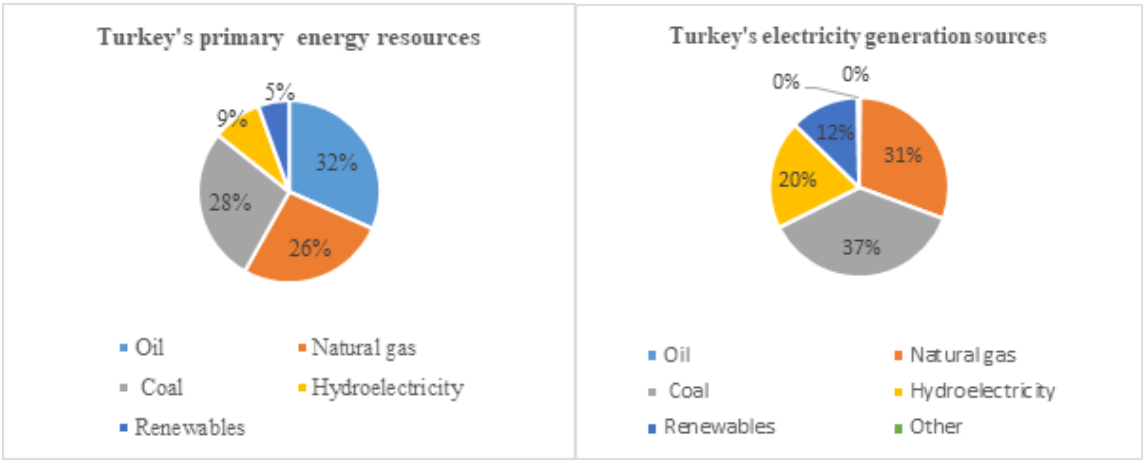

Figure 1. Turkey'sprimary energy consumption (on the left) and electricity generation (on the right) share by resources in 2018 [4].

Moreover, Turkey's energy consumption is heavily dependent on the other countries' resources. Figure 2 shows the increasing rate of imported energy for Turkey which reached to 75% in 2015 while it was 12% in 1960 [5]. Figure 2 also shows that the energy use per capita increased from 389 kg toe to 1651 kg toe from 1960 to 2015 [5]. Thus, the reason for the increased energy import rate can be attributed to the dramatic increase of energy use in the country along with the countries' limited fossil fuel reserves which are not sufficient to counterbalance the increase in energy use [6].

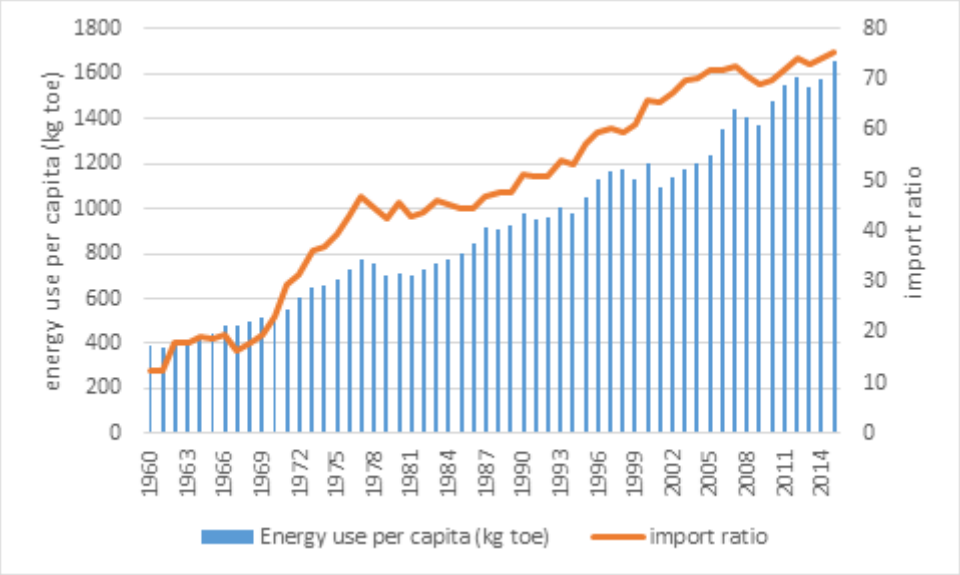

Figure 2. Turkey's energy use and import rate [5].

Therefore, it can be claimed that Turkey needs more clean and national energy resources in order to reduce the environmental impacts of fossil fuels and energy dependence. This study aims to present potential benefits of WTE for Turkey by putting into the perspective of renewable and national character of WTE.

II. WASTE MANAGEMENT AND WASTE-TO-ENERGY TECHNOLOGY IN THE WORLD

A. Literature review for Turkey

There is only a couple of studies focusing on WTE potential of Turkey in the literature. Baran et al (2016) finds that annual 230 GWh of electricity production can be generated by using distributed municipal solid waste [7]. However, they have not estimated economic and environmental benefits of such a potential. Lise (2017) also finds 750 MW capacity of WTE for Turkey [8]. This paper aims to fulfill the gap of more comprehensive approach of potentiality of WTE in Turkey investigating energy production, economical and environmental benefits using local calorific values of municipal solid waste in Turkey.

B. Current Status in the World

WTE technology has been increasingly developed since the beginning of concerns about the landfilling due to the land scarcity, increase of cost and environmental sensitivity [9]. Figure 3 displays the number of WTE plants by the countries [10]. It can be seen that, as of 2018, Japan has the most numbers of WTE plants in the world with 1162 plants followed by China with 299 plants. Among the E.U. countries, France has the highest number of WTE plants with 126 followed by Germany with 121 WTE plants as of 2018 [10]. It is also shown in Figure 3 that there was only 1 WTE plant in Turkey as of 2018 [10].

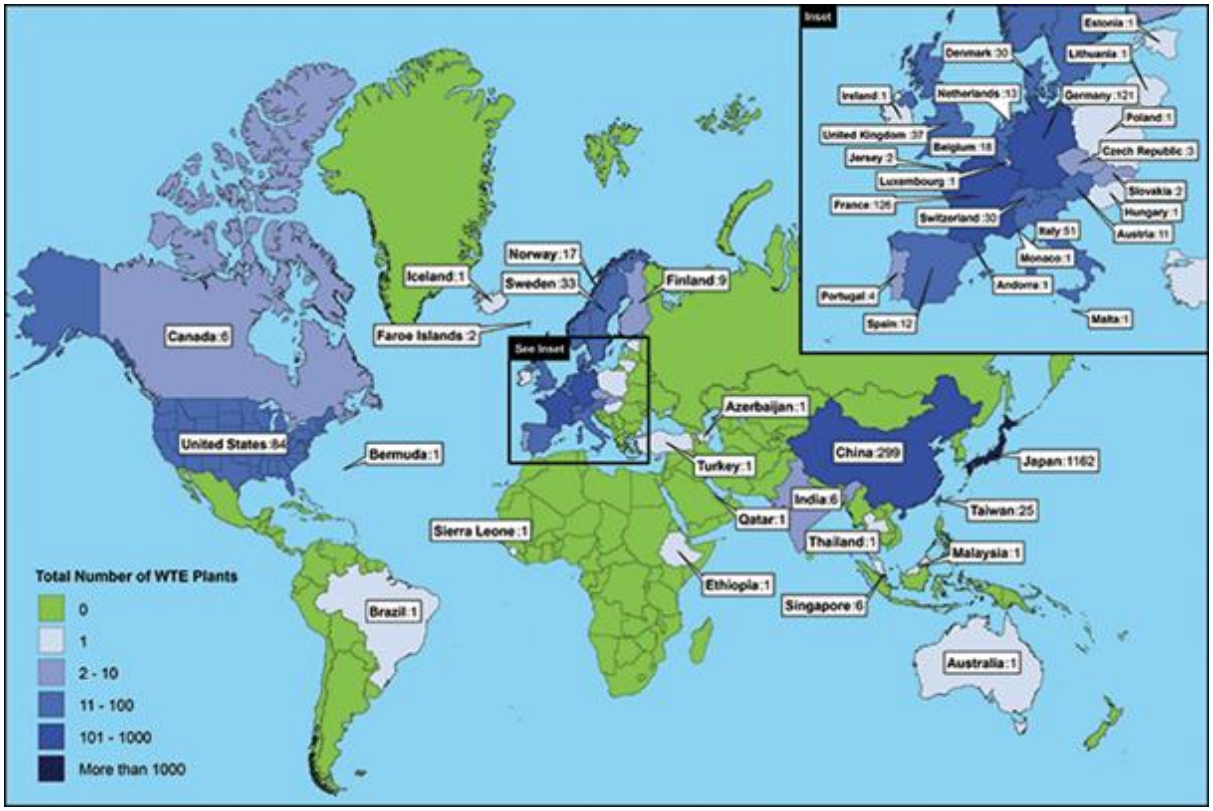

Figure 3. Map of WTE plants in the world by numbers [10].

Although the numbers of WTE plants are relatively lower than the abovementioned E.U. countries (Figure 3); Finland, Sweden and Denmark have the highest percentages of MSW treatment with WTE as a method with 57%, 53% and 51%, respectively as it can be seen in Figure 4 [11]. On the other hand, many countries including a few countries in E.U. have not benefited from WTE yet (Figure 4).

Figure 4 shows the MSW management method shares of E.U. countries. On average, 28% of the MSW is used for WTE in E.U. countries while the highest share of WTE is observed in Finland with 57%. It can also be seen from Figure 4 that recycling and WTE coexist in the urban development. For example, in 2018, Austria achieved 58% recycling with 39% WTE, Sweden 46% recycling and 53% WTE, Denmark 51% recycling and 48% WTE, etc. All these countries had established long term goals to 'move away from landfills' through a combined implementation of recycling and WTE. Turkey, on the other hand, still has 67% sanitary landfilling and 20% uncontrolled dumping as of 2018 [11].

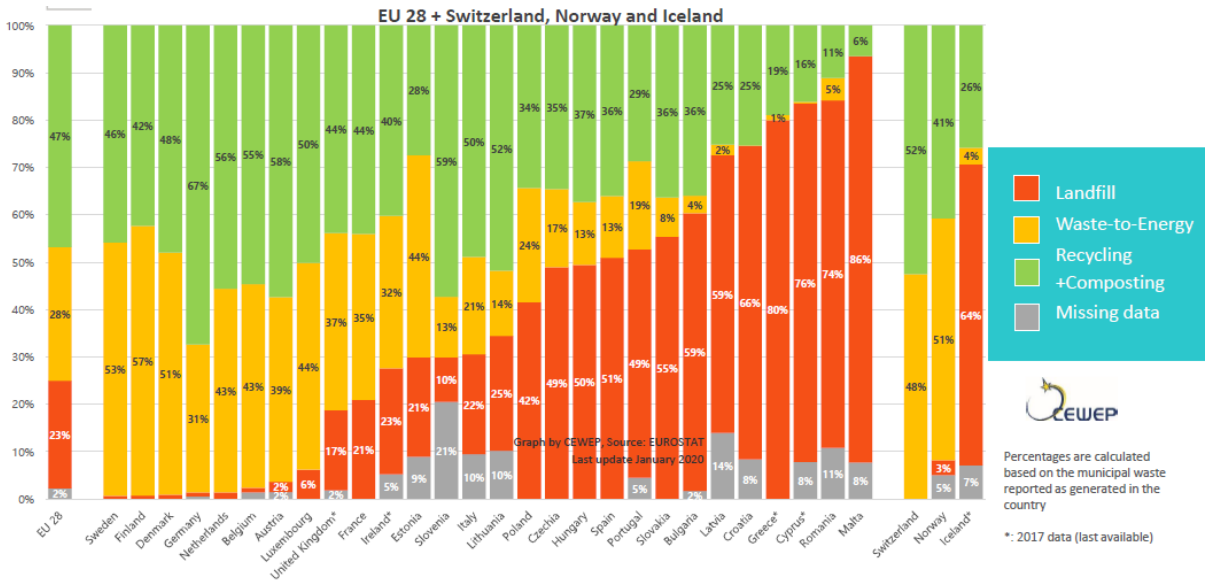

Figure 4. Share of MSW management methods in EU countries [11].

China recognized the problem of the open dumping of wastes and was alarmed by the increasing population and urbanization they faced the recent decades. They introduced WTE technologies to alleviate the problem of waste management. This was also associated with the limited time they had, and few cultural, technical, and regulatory elements of the system that did not provide room for education, and advancement of recycling/composting.

In China, a phenomenal growth is observed with the deployment of thirty to forty WTE plants per year since the beginning of the century, as shown in Figure 5 [12]. A comparison of the capital investment required in several countries of the world is provided in Figure 6 [13]. China has demonstrated that it is possible to reduce the capital cost of WTE plants by means of industrial and academic R&D, and mass production, instead of one plant at the time. In addition, the government was accepting most of the risk of the investment by participating in the equity structure, by providing strong tax and policy incentives, e.g. land permits, disposition of residues, energy credit, etc.; and becoming fully engaged in public education and acceptance of new WTE projects. All these actions were associated with significant reductions in the capital required for WTE. For instance, the WTE plant in Dublin, Ireland was commissioned in the late 1990s, but it was opened in 2018, mainly associated with the public opposition of the project. The capital investment required was ~$1,200/ton, as compared to ~$672/ton of the West Palm Beach plant in the US, and ~$190/ton of the plant in Nanjing, China.

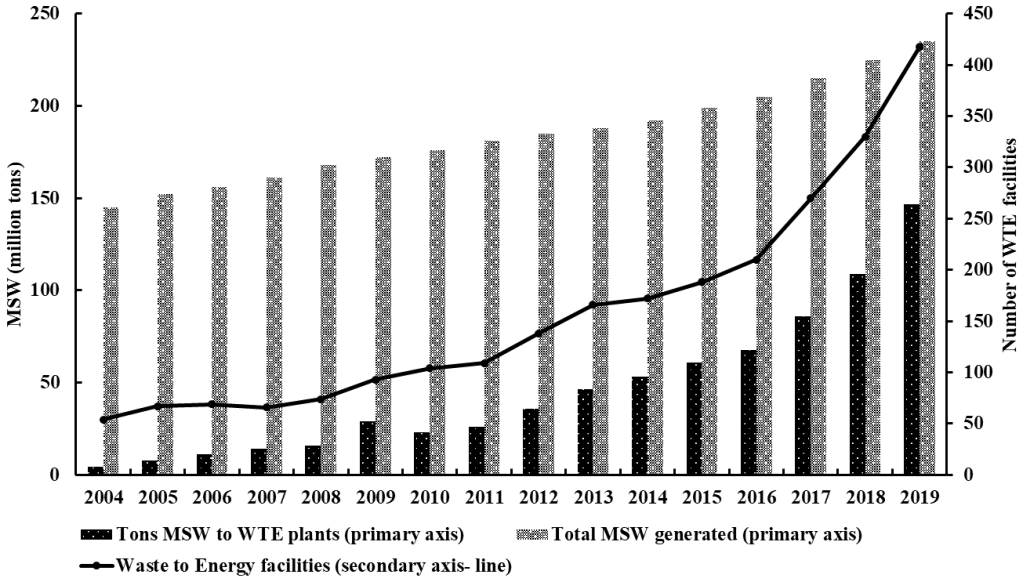

Figure 5. Growth of WTE in China [12].

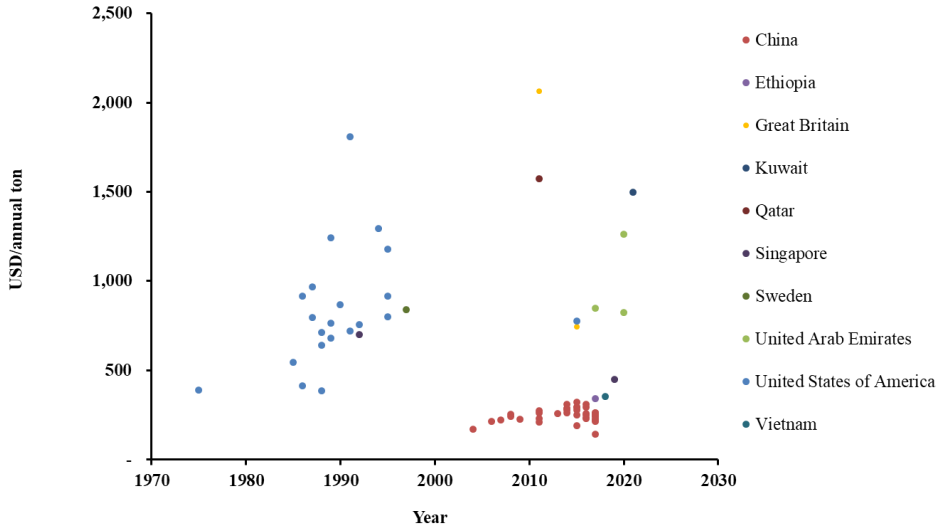

Figure 6. Cost of WTE by country (Adjusted for Exchange Rates and Inflation) [13].

The global experience has shown that two approaches have been used for the advancement of solid waste management (SWM) in communities:

- Developed nations took several decades to reach their present state of development and achievement in sustainable waste management through public education, citizen compliance, and the deployment of sophisticated systems. The integrated systems were designed upon maximum recovery of resources from the recyclable/compostable wastes, and the maximum recovery of energy from the residual wastes;
- China accelerated the phasing out of landfilling or the improper dumping by the massive application of WTE technology.

C. WTE Technologies

There are several technologies to recover energy from the waste such as non-thermal and thermal treatment methods. Anaerobic treatment which is a non-thermal method is good for organic waste treatment where MSW is not accounted for. Thermal treatment methods include incineration, pyrolysis, gasification and plasma gasification. Among the thermal treatment methods moving grate incineration is the most widely used technology in the world with 80% of the WTE plants [2]. Therefore, this study considers moving grate technology for estimating potential benefits of WTE for Turkey.

1) Moving grate technology

The Moving Grate (MG) technology has been in use since the middle of the last century and evolved from coal combustion. MSW is combusted on a grate at 950 to 1100°C with excess air and is presented in Figure 7. The grate moves slowly, in either reverse or forward action and primary air is injected under the grate. Secondary air is also injected to achieve full combustion in the water-cooled furnace.

The heat generated by combustion is transferred through water walls and superheater tubes to the high-pressure steam that drives the turbine generator. The low-pressure steam from the generator exhaust can be used for district heating.

The plants operate with state-of-the-art Air Pollution Control Systems (APCs), and that is why the emissions of all plants are significantly below the stringent nationally established limits. Selective Non-Catalytic Reduction (SNCR) is typically used to reduce NOx emissions by 70%. However, many European, and a few US plants use both SNCR and Selective Catalytic Reduction (SCR) to reduce NOx by >90%. WTE plants use in-bed lime injection able to remove more than 95% of Sulphur, activated carbon injection for the complete destruction of dioxins/furans and bag filters or Electrostatic Precipitators to remove fine particles.

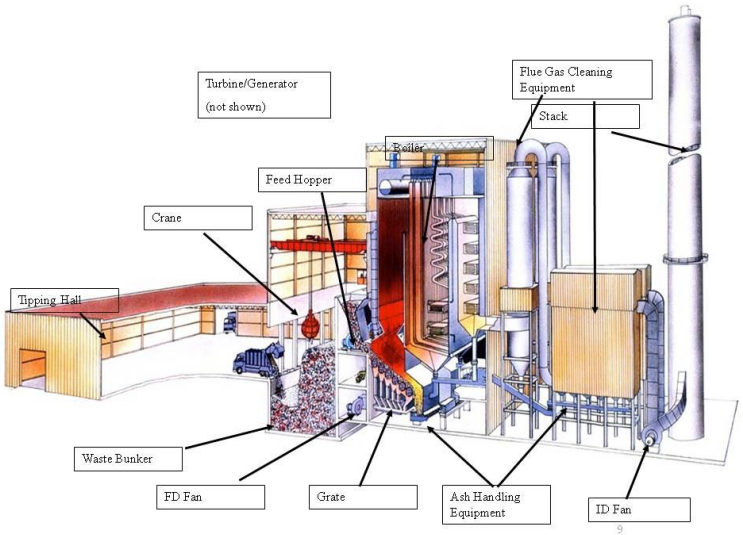

Figure 7. Parts of a moving grate WTE facility [2].

2) Sitting of WTE plants

The perception that WTE facilities are undesirable neighbors from an esthetic viewpoint has also been an obstacle to the development of WTE. However, modern WTE facilities operating in the U.S., Europe, Japan, and other nations have been designed with this concern in mind. WTE plants located

in the center of architecturally sensitive cities, such as Vienna, Osaka, and Paris, have shown that designs can be made compatible with local esthetic requirements. An analysis of primary data estimated that the average distance of WTE plants from the city center that these plants are serving is ~five kilometers, as presented in Figure 8 [14]. Most of the plants in Japan, and EU are located close to the city centers. Most of the outliners were plants located in the US.

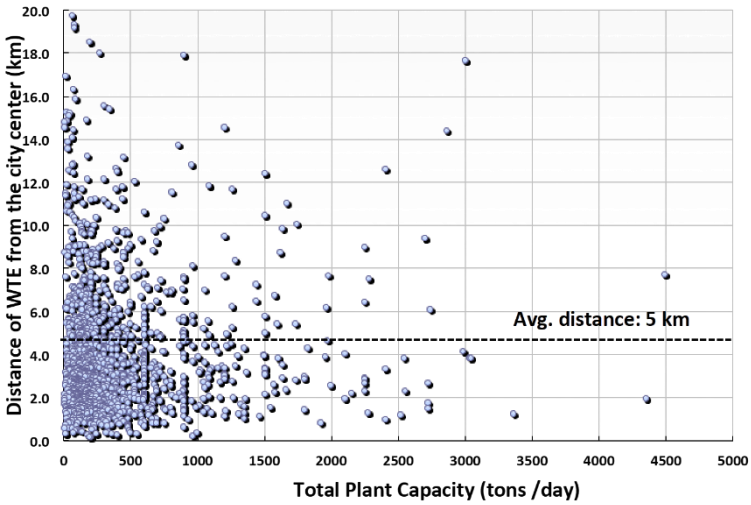

Figure 8. WTE capacity (x-axis) vs. distance of WTE from city center (y-axis). The analysis represents all the ~1000 WTE plants of the world. [14].

III. WASTE MANAGEMENT IN TURKEY

Municipalities are responsible for municipal solid waste management in Turkey. The total amount of MSW was around 25 million tons in 2001, with a 28% increase in 17 years it reached around 32 million tons in 2018 [15]. As it can be seen from Figure 9, dumping was the dominant MSW treatment method in 2001 for the country whereas sanitary landfilling became the most dominant MSW treatment method in years. Also, material and energy recovery which is summed up by the data supllier from MSW is developing recently in the country.

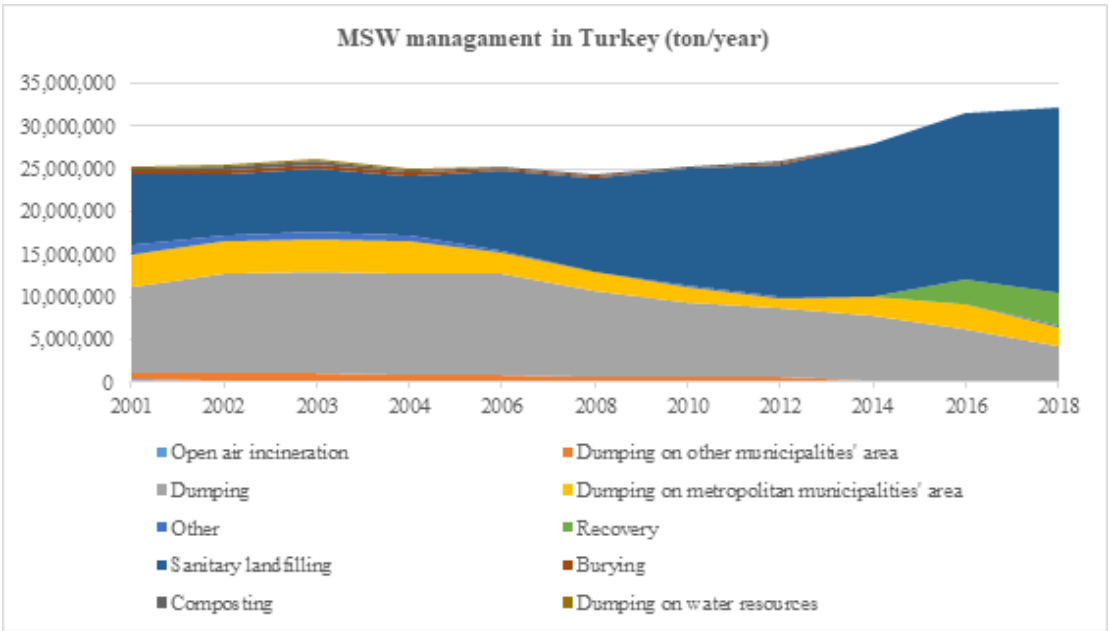

Figure 9.Amount of MSW by treatment methods between 2001-2018 in Turkey[15].

Figure 10 shows the share of MSW amount by the treatment methods in Turkey in 2018. It can be seen from Figure 10 that sanitary landfilling and dumping treated 87% of all MSW in the country while energy and material recovery was gained from 12% of MSW. Composting was applied to only 1% of the MSW in the country.

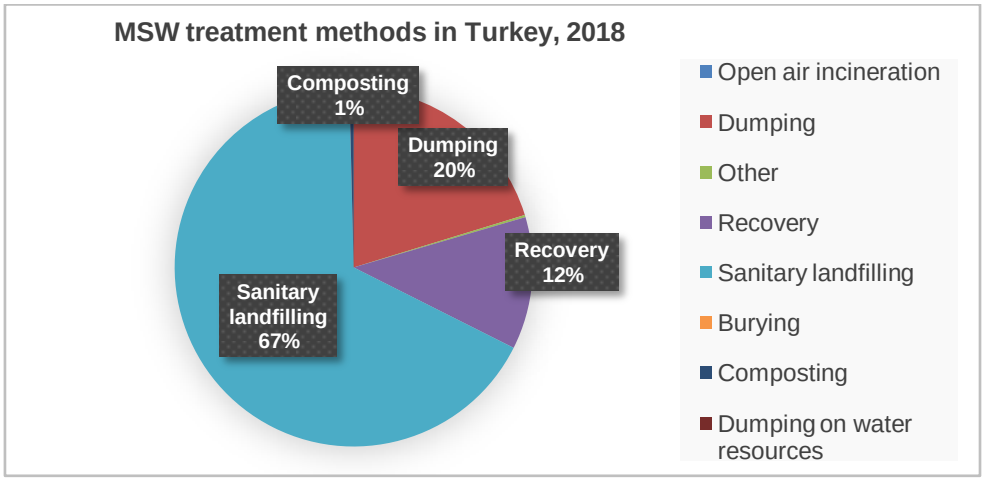

Figure 10. Share of MSW managed by different methods [15].

IV. POTENTIAL BENEFITS OF WASTE-TO-ENERGY FOR TURKEY

In this study, we consider three scenarios which consist low, medium and high landfilling scenarios for WTE integration to the current status of Turkey's MSW management. In the first scenario, it is assumed that 10% of MSW is managed by the WTE method; in the second scenario it is assumed that 30% of MSW is managed by WTE; and in the high end-scenario it is assumed that 50% of MSW is treated by WTE.

A. Benefits to electricity mix

Calixto (2017) estimated calorific value for Chilean MSW as 8.73 MJ/kg which corresponds to net gained electricity of 0.56 MWh/ton considering all losses [16]. However, Yildiz et al. (2012) determined average calorific value of MSW for Istanbul is estimated as 6 MJ/kg [17]. Considering Istanbul is the biggest metropolitan of Turkey which hosts almost one fifth of all population in Turkey, the calorific value for MSW of Istanbul is adopted for this study. Using the same efficiencies that Calixto (2016) assumed, net gained electricity from collected waste in Turkey is determined as 0.38 MWh/t for this study [16].

Table 1 summarizes expected electricity generation from WTE and its share in electricity mix based on 2018 data. For the calculations in Table 1, the total amount of produced energy in 2018 is taken as 304.8 TWh [18]. Results of the calculations show that if 50% of the MSW in Turkey is used in WTE plants to produce electricity 2% of the countries' electricity would be supplied from the solid waste.

Table 1. Annual expected electricity generation from WTE and its share in the electricity mix.

Scenarios	Expected annual electricity generation	Share in electricity mix
Scenario 1 (10%)	$0.38*(32*10^6)*0.1= 1.2$ TWh	1.2/304.8 = 0.4%

Scenario 2 (30%)	$0.38*(32*10^6)*0.3$= 3.6 TWh	3.6/304.8 = 1.2%
Scenario 3 (50%)	$0.38*(32*10^6)*0.5$= 6 TWh	6/304.8 = 2%

B. Benefits to the economy

In this study, WTE is assumed to replace natural gas power plants since natural gas is mostly imported in Turkey and it is wanted to be reduced to minimize dependency on other countries as well as reducing the budget deficit. The economic benefits are estimated for the third scenario of using 50% of the MSW in WTE plants. Capital cost of WTE plants are estimated as 305.3$ per ton of MSW and operational cost is estimated as 12.82 $ per ton per year whereas gate fee is taken as 18 $/ton per year [16]. On the other hand, Kocaoglu (2009) stated that capital cost of a natural gas power plant and operational expenditures are 650$/kW and 0.03 $/kWh, respectively [19]. Table 2 shows the comparison of costs of investing on WTE and natural gas plants. It can be seen from Table 2 that annual cost for WTE and natural gas plants are 79.9 MM$ and 201.7 MM$, respectively, which corresponds to 121.8 MM$ per year of savings for the country.

Table 2. Cost comparison between WTE and natural gas power plants

Expenses & Revenues	**3rd scenario (6 TWh annual energy production)**	
	WTE (1280 MW) - 30 year lifetime [17]	Nat. Gas (1000 MW) - 30 year lifetime [20]
Capex	305.3 $/ton	650 $/kW
Opex	12.82 $/ton per year	0.03 $/kWh
Gate fee	18 $/ton per year	-
Total cost ($ per year)	79.9 $ MM	201.7 $ MM

C. Benefits to the environment

Psumopoulos et al. (2009) stated that landfilling requires 30 times more area than using WTE for waste management method [20]. Therefore, considering the scenario of 50% of the waste which is 16 million tons of MSW being treated by WTE, the required land use is estimated as 1.6 million m2 where this area would be needed if landfilling is in use per year. Therefore, it is estimated that 46.4 million m2 area would be saved from landfilling in the 30 years lifetime of WTE plants which corresponds to 1.55 million m2 area per year.

Moreover, CO2 emissions from WTE plants is asserted to be lower than natural gas power plants [21]. O'brien (2006) states that a WTE plant emits 379.66 kg CO2 per MWh whereas a natural gas power plant emits 514.83 kg CO2 per MWh. Therefore, considering the scenario of 50% of the MSW which is 6 TWh electricity production being generated, WTE plants could reduce 135.2 ton CO2 emissions per year replacing natural gas power plants. On the other hand, landfilling of 16 million tons of MSW contributes to 1.54 million tons of CO2 and 571,424 tons of methane emission which could be eliminated if treated by WTE plants [21].

V. CONCLUSION

The aim of this study is to provide a snapshot of the current status of waste management in the world, provide evidence on the role of WTE in sustainable waste management, and assess the benefits of such technologies for the case of Turkey.

The global experience has shown that two approaches have been used for the advancement of solid waste management in communities:

- Developed nations took several decades to reach their present state of development and achievement in sustainable waste management through public education, citizen compliance, and the deployment of sophisticated systems. The integrated systems were designed upon maximum recovery of resources from the recyclable/compostable wastes, and the maximum recovery of energy from the residual waste.

- China accelerated the phasing out of landfilling or the improper dumping by the massive application of WTE technology.

The general benefits of WTE can be summarized below:

1. Produces energy from waste that cannot be recycled, and it is typically landfilled. Recycling processes themselves inherently generate wastes and residues. WTE can help recover energy from these residues.
2. Successful examples of the world have proved that recycling goes hand in hand with WTE.
3. WTE is key to remove hazardous materials out of the economy.
4. Allows recovery of metals and minerals from non-recyclables.
5. Saves land (1 m^2/ 10 tons of MSW) and GHG (1 ton of $CO_{2\text{-eq}}$/ton of MSW) over landfilling that emit methane.
6. the "turns" or "cycles" in an economy need energy that can be provided by WTE.

For the case of Turkey, WTE deployment will be associated with the savings of ~$122 MM per year. Also, WTE can contribute up to 2% to the electricity demand of the country, and can lead to the savings of ~ 1.5 million tons of $CO_{2\text{-eq}}$ and ~1.6 million m^2 of land; besides, the aesthetic superiority as compared to the only alternative, which is landfilling.

ACKNOWLEDGMENT *(Heading 5)*

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Design Analysis for Cold Storage Using Concentrated Solar Power

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ABSTRACT

There has been huge increase in usage of renewable energy throughout the world in past few years and solar energy is one of those. The main contribution to this increase has been due to cost reduction of solar PV systems which can convert solar energyinto electric energy. But solar energy can be utilized in other ways too. Instead of converting solar energy into electrical energy we can use heat of sun in different ways. One of the applications can be to use this energy for the purpose of cooling/cold storage using VARsystem.

Cold storages are an important part of value chain of agriculture. Agricultural commodities are perishable therefore decentralized cold storage system can help in long term storage of these commodities which could help farmers in increasing their income. Also long term storage would help in decreasing the food wastage and controlling the food inflation in India. These things will also help India in maintaining the food security and increasing the exports of agriculture commodities.

Therefore, this paper contains analysis for the possibility of using solar energy for the purpose of cold storage in rural areas where electricity has not reached yet or there is insufficient supply of electricity. For this purpose, we have studied solar cooling system (AC system) of 100 KW capacity present in technical block of National Institute of Solar Energy. Then accordingly we have analyzed the possibility of designing a cold storage whichcan be used in rural areas for storage of agricultural commodities.

Keywords— *Cold Storage, Vapor absorption Refrigeration(VAR) System, Concentrated Solar Power(CSP)*

I. INTRODUCTION

Renewable energy is continuously growing in the world and a lot factors have contributed this growth. One of the biggest factors is the cost for utilizing the renewable energy is continuously decreasing therefore both developed countries and developing countriescan effectively utilize the potential of renewable energy.

In India, Government of India is continuouslypressing on the need of increasing the percentage of renewable energy in the total energy production. One of the major ambitions of Indian Government is to increase the renewable energy potential to 175GW till2022.

Hence, various schemes related to increasing the potential of India in effectively utilizing the renewable energy are being launched. This includes Nation solar mission, solar parks, Nation biofuels mission, etc. If we see the data for 2019, the percentage of renewable energy for power generation has reached 23% which accounts for above 85000GW.

Among renewable energy, solar and wind energy accounts for major of its portion. This is because India has immense solar energy insolation from sun. This is mainly due to geographical position of India which lies in the tropical area of world.

In India, maximum energy is produced with the help of wind energy. This mainly includes areas of Gujrat, Karnataka, Kerala, Madhya Pradesh, Andhra Pradesh, Maharashtra, Telangana, Tamil Nadu and few other states. Then the second highest contribution is from solar energy. This solar energy has been mainly utilized with the help of solar panels which is a very effective technology to convert solar energy to electric energy. But the drawback is that it is not efficient and in future it can create immense problem of electronic waste. Therefore, there is need to develop technologies which can be efficiently used in different applications.

II. NEED FOR SOLAR BASED COLDSTORAGES

India has advantageous geographical position in terms of solar potential. It lies between tropic of cancer and equator which gets immense solar insolation. The need of the hour is to harness that solar energy to better utilise in various applications by different efficient technologies. The good thing is that India is trying to harness that solar potential by various forms. In past few years it has taken a big jump in increasing the solar photovoltaic to harness its potential. India has started with various programs to increase the useof solar energy it both urban and rural India. Most of those programs are driven with help of solar panels. This is because solar panels have been most successful in effectively using solar energy to convert it into electricity and then they can be used anywhere.

Therefore, most of solar based cooling system are driven with the help of solar panels and work using VCR cycle. Also the other methods to harness solar potential have not been developed effectively. But the there are various problems with solar panels too.

Firstly, the efficiency of solar panels in harnessing the solar energy has been very low and various institutes are doing the research to increase its efficiency.

Secondly, it can produce huge problem to electronic waste in the future because India still does not have effective policy in tackling the e- waste. Most of the e- waste are handled by informal sector which can be hazardous for both environment and labors handling the e- waste.

Therefore, there is need to develop solar based cooling system which can be used in rural and remote areas which can efficiently harness the solar potential to use it in for application in the cold storage. This can be done by using vapour absorption cycle which does not need solar panels and it can directly use the heat of sunlight to develop solar based cooling system.

III. ENVIRONMENT FORSTORAGE

S.NO.	Fruits/Vegetables	Temperature range (°C)
1	Apples	-1 - -4
2	Bean/Carrots/Cauliflowe r	0
3	Litchi/Orange	4-7
4	Onions	0-2
5	Strawberries	0
6	Sprouts	0-2
7	Potatoes	4-10

Table 1 –(Storage environment for different fruits)

The main application of cold storage is to provide an environment that would help in long term storage of agricultural products while maintaining the quality. This includes controlled level of temperature, humidity and air circulation within the cold storage. Also the agricultural products would keep releasing the heat. Therefore, the temperature has to be continuously monitored and controlled. Hence temperature control becomes the most important factor for controlling the environment inside thecold storage.

IV. COLD STORAGE ININDIA

Cold storages are an important part for agriculture in India. It is used for the storage of different food crops in refrigerated condition. By 2014, 727 lakh metrictons of storage capacity of food grains were already present. According to Press Information Bureau of Government of India 1303 cold storages were established between 2015-16 and 2019-20 with total capacity of 45 lakh metric tons. Despite this India has huge deficiency of cold storages and the existing facility is available to very few farmers.

Before green revolution, India was dependent on imports for agricultural products because Indian agriculture was primitive and there was absence of usage of technology in agriculture. But India became self- sufficient in agriculture after green revolution. This was a major success in achieving food security. But despite achieving food security, India has maximum number of malnourished children. According to Global hunger index 2019 India was ranked 102 among 117 countries. Every year tons of food grain gets destroyed due to lack of cold storage facility. Proper cold storage facility along with effective and efficient public distribution system could have avoided malnourishment and wastage of food grains to some extent.

V. COLD STORAGETECHNOLOGY

Cold storage refrigeration can be achieved using two technologies i.e.

1.) Vapor absorption refrigeration (VAR) – This technology has high instalment/initial cost but its operational cost is low and helps in saving the energy. However, it has limitation because coefficient of performance is low and it is difficult to achieve very low temperature through this technology.

2.) Vapor compression refrigeration (VCR) – This is cheaper technology in comparison to VAR. Most of the cold storages use this technology for refrigeration. It uses more energy than VAR system and coefficient of performance is better than VAR system.

This paper will mainly deal with vapor absorption refrigeration system to analyze the design for cold storage.

V. DESIGN ANALYSIS OF SOLARBASEDCOOLING SYSTEM

Cold storage can be made using solar power by two ways. One is using solar photovoltaic panel and other is using solar thermal collector. The diagram (Fig- 1) shows the detailed flowchart of two technologies.

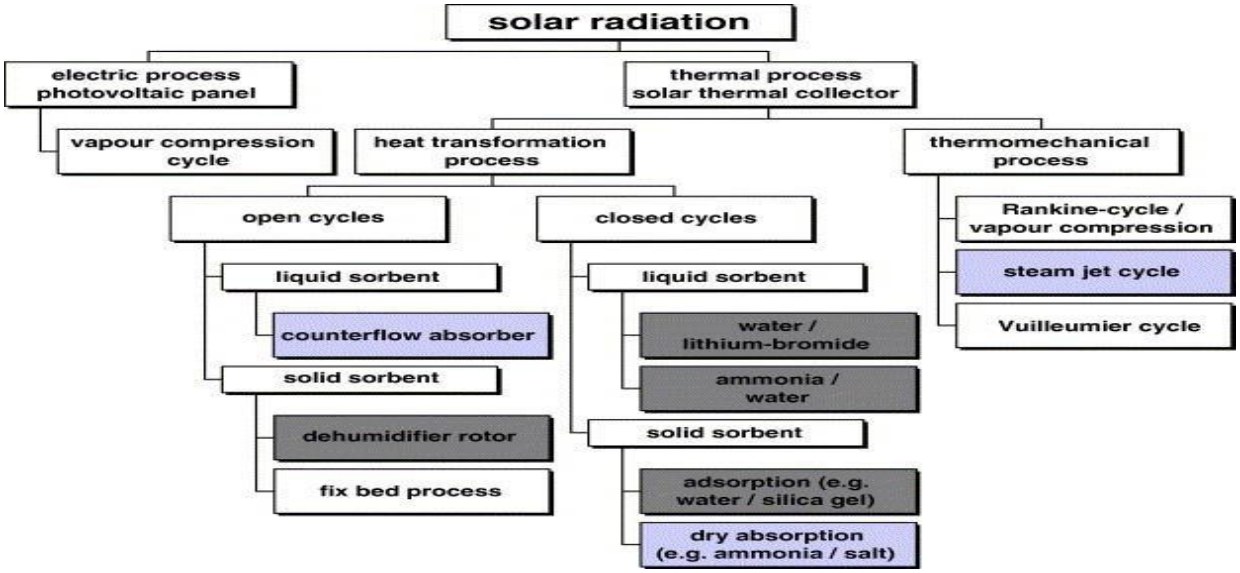


FIG – 1 (FLOWCHART OF DIFFERENT ROUTES OF SOLAR COOLING)

We have analyzed different technologies in National Institute of Solar Energy that are being used for different purposes. But we will be dealing specifically with design of triple effect solar cooling system (for the purpose of air conditioning) used at National Institute of Solar Energy. Then we will try to understand the design modifications required in the cooling system to use it for the purpose of refrigeration or cold storage.

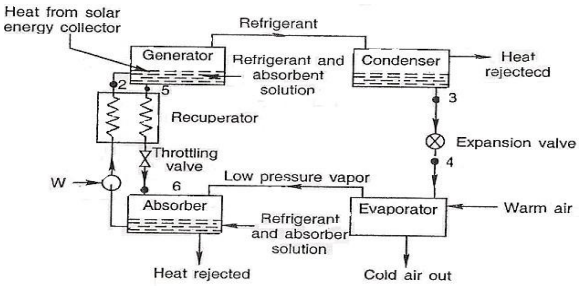


Fig- 2 Diagram of VAR cycle

A. DESIGN ANALYSIS

Cold storage using concentrated solar power should use vapour absorption refrigeration system for cooling purpose.

The basic design should consist of a solar thermal collector to collect the heat energy from sun, generator, absorber, pump, refrigerant, absorbent, evaporator and condenser.

But for cold storage system we need a more efficient system to maintain a low temperature inside the cold storage. For this purpose, different types of absorptionsystems are available. This includes single effect absorption system, double effect absorption system, double effect absorption system and triple effect absorption system. Every system needs different input temperature and each has different efficiencies.

B. SOLAR THERMAL COLLECTOR

Different types of solar thermal collector are available. Each collector has different characteristics.

Solar thermal collectors are of two types:

B.1 Non- concentrating (Flat plate collector)- These have generally flat surfaces to collect the solar energy. Hence it does not concentrate the solar energy at one point. Typically, it consists of three parts i.e. transparent sheet, absorber and pipe. A flat plate collector has very lowefficiency. Therefore, it can cannot increase the temperature inside the generator of VAR cycle to desired level. Hence, it would be impractical to use it for the purpose of cooling. But it can be used for other purposes like water purification and desalinization.

B.2 Concentrating Solar Power (CSP) / Concentrating Thermal Collectors

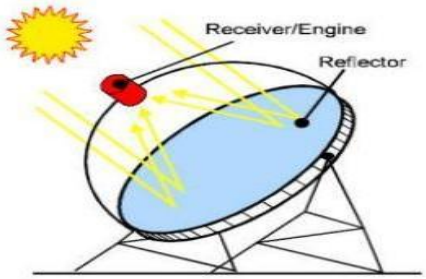
Different types of concentrating solar thermal collector are available to get the required temperature for generator of VAR cycle and each system has different thermal efficiency. Also every one works on same principle that is the light gets reflected with help of reflector and then an absorber is present in absorb the light to increase the temperature of the fluid. The innovative idea of concentrated solar power is that it captures and concentrates the incident sun rays to provide the heat required to heat the flowing fluids and so that the flowing fluid may be use for different purposes. Another aspect of CSP plants isthat this can be equipped with a heat storage system in order to generate electricity even when the sky is fully covered with clouds or after sunset. This significantly increases the CSP capacity factor as compared to solar PV system and, mostly it helps in the production of dispatch able electricity, which can be beneficial for both grid integration and economic competitiveness.

Therefore, CSP technology benefit from advancement in solar concentrator and thermal storagetechnologies, while other components of the CSP plants are based on rather mature technologies and may not to be expect to see rapid costreductions.

CSP plants can be divided into two group, the firstone is the solar collectors concentrate the sun rays along a focal line and the second one is a single focal point (very high concentration factors). In line-focusing systems, it includes parabolic trough and linear Fresnel based plants and it have single-axis tracking systems. In point-focusing systems, it includes solar dish systems and solar tower based plants and it has two-axis tracking systems to concentrate the energy of the sun. CSP plants needed adequate direct solar radiation in order to heating the working fluid. As we know that only strong direct sunlight can be concentrated to the temperatures required for heating flowing fluids. This limits CSP to hot, dryregions.

Economically at present, requires a CSP plant with direct normal irradiance levels (DNI) of 2 000 kWh/m2/year or even more There are many parameters that are responsible for optimum plant designing but thermal energy storage plays main role in designing. It increases costs, but allows higher capacity factors, dispatchable power generation when the sky is cloudy. So due to investment in thermal energy storage, cost also increases.

Different types of concentrating solar thermal collector are available to get the required temperature for generator of VAR cycle and each system has different thermal efficiency. Also every one works on same principle that is the light gets reflected with help of reflector and then an absorber is present in absorb the light to increase the temperature of the fluid.



B.2.I. Parabolic dishsystem

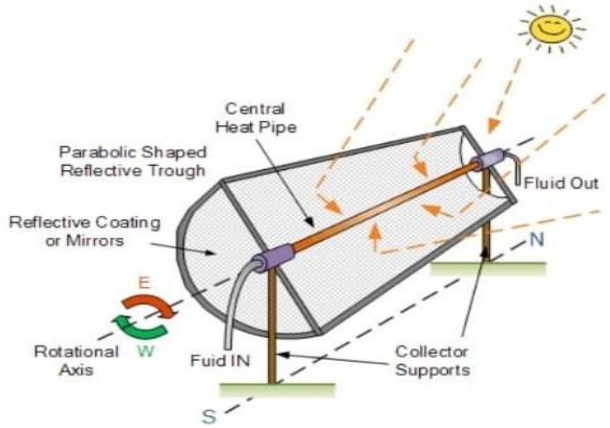
Figure- 3 (Parabolic dish system)

Parabolic disk collector is among the latest innovations in the field of solar thermal collector. The biggest advantages are

1.) It has very high efficiency and losses are negligible. Hence, it can increase the temperature very high in comparison to other solar collectors.

2.) It requires less space/ foot print. Therefore, it can be used at uneven terrains like mountains or region with high slope whereas other systems cannot be used.

3.) It does not require large cooling systems



B.2.II.Parabolic trough collector(PTC)

Figure- 4 (Diagram of Parabolic troughcollector)
Source: Alternative Energy Tutorials

It consists of four different parts namely reflector, collector, absorber, motor.

Reflector can be made up of solar grid aluminium and it is parabolic in shape. Collector is a transparent tube present at the focus point of reflector plate. Absorbers is present inside the collector to absorb the sunlight. It is of black colour to efficiently absorb the sunlight. The heat transfer fluid (Usually water) flows inside the collector to transfer the heat from PTC to vapor absorption machine (VAM). Motor is used to rotate the reflector to efficiently capture the sunlight at different position of the day. This system is generally aligned along North-south direction because the sun moves from east to west. This helps in maximum capture of energy. Main advantage of PTC is that it has high efficiency and it can increase the temperature up to more than 200 degrees Celsius in the VAM.

It is most widely used technology among CSPs. But there is possibility of improvement in performance and cost reduction. It is the fully grown technology and lower chances in development risk. Parabolic

troughs collector and solar tower technology when work together with thermal storage system gives better performance and can meet required demand.

B.2.III.Power tower system

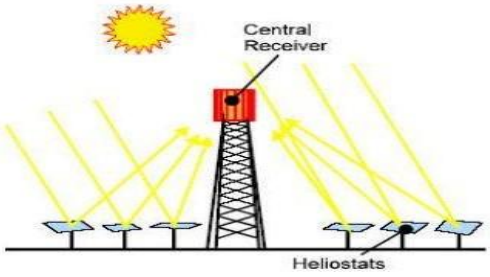


Figure- 5 (Diagram of power tower system)

Power tower system uses a mirror (called heliostats) which track the movement of sun. The sun rays get reflected from mirrors to a receiver present at top of the tower. The tower is present between the mirrors. The main features of this system are

1.) The system is more efficient and can increase the temperature of the fluid up to 600 degrees Celsius. Therefore, it can be also used in turbine generator system to produce electricity using high pressured steam.

2.) It can also help in efficient thermal storage. Because higher temperature generation helps in increased thermal storage within the same cost.

3.) When solar tower system works on higher temperature by using molten salt or other alternative as a heat transfer fluid with thermal energy storage system have great potential for minimizing cost and gives better efficiency.

4.) So, solar towers when works by using molten-salt as a high temperature heat transfer fluid and storage medium may be the best CSP technology in future, this is due to minimum energy storage costs, by high capacity factor, better efficiency of the cycle and their optimum output capability.

B.2.IV.Linear FresnelSystem

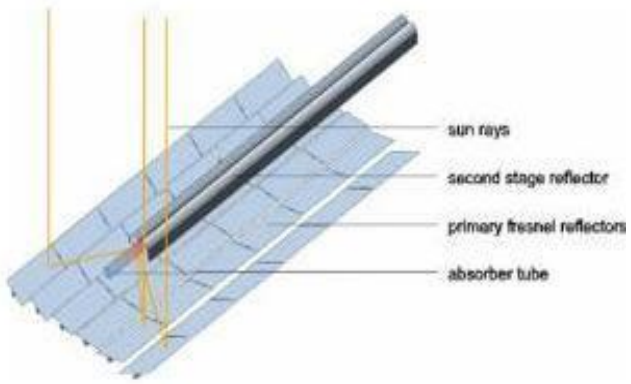


Figure- 6 (Diagram of Linear fresnel System)

This system is very similar to trough collector system. It has large number of collectors which are placed in parallel. The mirrors are placed flat and light reflects towards absorber pipe placed at center of mirrors.

Each line of mirror contains a tracking device. This helps in individual tracking of each line of mirror and maximum amount of solar energy is captured using absorber.

There are many advantages of this system in comparison to PTC.

1.) It uses flat mirrors. Therefore, mass production becomes easier. This helps in cost reduction

2.) The wind pressure/ load on this system is lower. Therefore, it also has better structural stability.

3.) The surface of mirror per receiver is greater in this case.

But there are some disadvantages too.

1.) The optical efficiency is lower.

2.) The cosine losses of the system are greater.

Solar tower and linear Fresnel systems also have potential to minimize their capital costs and improve the unit performance. But due to longer running experiences of parabolic trough collector technology, it is most reliable.

C. REFRIGERANT AND ABSORBENT

Water – Lithium Bromide absorption system has a lot of advantages. It is non-toxic and inflammable. Its COP is also higher than ammonia-water absorption system. it can be easily used for the purpose of air conditioning using solar energy as input. But it cannot be used for refrigeration purpose because temperature below 4 degrees Celsius cannot be achieved. But negative temperature is required for refrigeration purpose.

Ammonia water absorption system can be used for both air conditioning and refrigeration purpose.

Condenser is both air cooled and water cooled. Also this system does not have crystallization problem but water – Li Br system has major problem of crystallization. In the operation of an H2O/LiBr absorption chiller, a crystallization of the solution has to be avoided by internal control of the heat rejection temperature in the machine.

Another advantage of ammonia water absorption system is that it does not need cooling tower which is required in case of water- lithium bromide system.

But the disadvantage of this system is that since absorbent(water) is volatile, a part of it gets vaporized and goes with the refrigerant vapor, and therefore, a rectifying system is required.

D.VAPOUR ABSORPTION MACHINE (VAM)

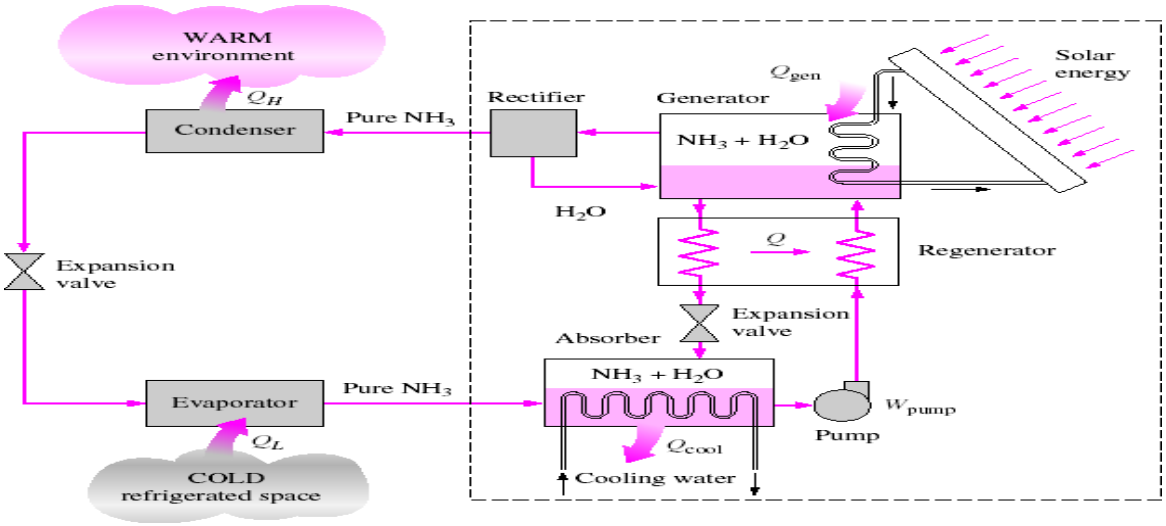


Fig – 7 (Vapor absorption machine using ammonia water absorption system)

It consists of absorber, generator, heat exchanger, pump generator, rectifier, evaporator, condenser, absorbent and refrigerant.

When we use vapor absorption machine using ammonia water absorption system then very low temperature of up to -20 degrees Celsius. Also the input temperature required for this system is between 140- 160 degrees Celsius. Hence it can be easily used for storage of food items. But COP of this system is very low (0.6 - 0.7). If we want to increase the COP of the system, then double effect refrigeration system needed to be used. But double effect refrigeration using ammonia water absorbent system requires very high input temperature which is very difficult to achieve using solar energy alone. Hence, it we need an additional source of heat energy (example: waste heat of an engine) to provide very high input temperature. If we need very high temperature using solar energy alone then there is a need for change in design of solar thermal collector to make it more efficient and effective.

VI. OVERALL DESIGN POSSIBILITY

We analyzed various CSP technologies. Solar tower and Fresnel systems are quite thermal efficient but not commercially prove. Therefore, it would be better to use parabolic trough collector for CSP because it is commercially proven and it can increase the temperature up to 550 degrees Celsius. This temperature is optimal for ammonia water refrigerant system.

For the purpose of cold storage, we should use ammonia water absorption system. But this system also has safety concerns. Therefore, adequate safety measures have to be taken while designing the system. Also, when the system is operational there might beconcerns regarding leakage of refrigerant which can be dangerous for human health.

Vapor absorption machine can be designed according to figure 7 which should also contain rectifier.

Therefore, overall system can be designed accordingly.

VII. CONCLUSION

We have analyzed the design of solar cooling system present at N.I.S.E. Accordingly we have tried to analyze the possibility of designing a cold storage by CSP using VAR system. It was analyzed that we can design cold storage using CSP which would can be easily used at rural areas for storage of agricultural products. The space taken for this system would be large in comparison to conventional systems due to usage of solar field for CSP. Also the space available in rural areas are abundant.

Therefore, this system can be easily installed in rural areas. This system will have high initial cost and 3/4thof total cost would be initial cost. The rest of the cost would be operational and maintenance cost.

This system would use PTC as solar thermal collector, ammonia as refrigerant, water as absorbent and a vapor absorption machine.

But, there was need for further detailed analysis which could involve detailed calculation for design of each part of the system. The detailed calculation could have given more insights into the design of cold storage.

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A Review on Agricultural Mobile Apps for SustainableAgribusiness: before and during Covid-19 Pandemic

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ABSTRACT

The spread of novel coronavirus Covid-19 at the beginning of March 2020 significantly impacted agribusiness especially fruits and vegetables. The closure of schools, restaurants, offices, and others has shifted supplies of agribusiness to retail channels. One of the prevailing issues faced by farmers in managing crops and finding a conducive place to market their products. In this view, the farmers' marketplace needs to evolve to continuouslysupply farmers' productsto consumers. Agriculture itself is undergoing a fourth revolution triggered by the use of information and communication technology (ICT).This paper provides insights into how mobile app technologies can assistto solve the agribusiness problems likesoil degradation, excessive water, emissions, pollutions, the marketplace,etc.We find mobile app features have widely developed for farmers, distributors, and producers to gather valuable data, observe fields, and manage crops to optimize the processes. Mobile apps and cloud computing become a center of solutions. In this global pandemic, providing support to farmers with useful and practical agricultural information can improve their economic development and eventually give a good impact on the country.

Keywords—*mobile apps; agribusiness;covid19;sustainable*

I. INTRODUCTION

The Covid-19 pandemic has impacted the supply chain worldwide and someinternational industries have been scale back to the domestic level. Farmers are a crucial part of the supply chain whohave to adapt to a new and uncertain future.Fortunately,in these few years before the pandemic, farmers and the agribusiness industry were actively embracing technologies. One popular article has reported the rapid growth of agriculture technologies and predicted technologies like IoT devices, drones, and software to be worth over $15 million by 2025. Since purchasing technologies and farm management software is a pricey decision, moving directly to a smaller scale of agricultural apps becomes a strategic alternative. Especially variety of apps are available in the market and they can be installed on many platforms like Androids and IOS. Recently, plenty of mobile apps have appeared for individual farmers and demand is still increasing particularly in the pandemic situation. This trend has given room for mobile apps developers to meet farmers' demands.

The objective of this study is to review the current literature and popular articles regarding the available mobile apps that have been developed to support agribusiness especially farmers. This paper is organized as follows: Section II explains the methodology of the search that is carried out in this study, section III discusses the findings of the search, and section IV concludes the explanation.

II. METHODOLOGY

This paper applies a systematic search to identify relevant articles published in open databases from 1 January 2016 until 31 October 2020. The databases used were Directory of Open Database Journal and Ebscohost. Additionally, some publications were searched on Google Scholar from the reference lists of included studies and reviews by backward and forward snowball searches. In opposition to scholarly materials, this study includes popular articles that refer to the material for the general public. The popular articles were inspected on Google search engine using "mobile apps agriculture" keywords and review was conducted towards the top 3 of the Google results. Theselection criteria for both scholarly materials and popular articles are: English written articles and the mobile app's products are relevant to agriculture fields. For scholarly materials, the articles were from peer-reviewed journals or conferences. The overall searching methodology is depicted in the following figure.

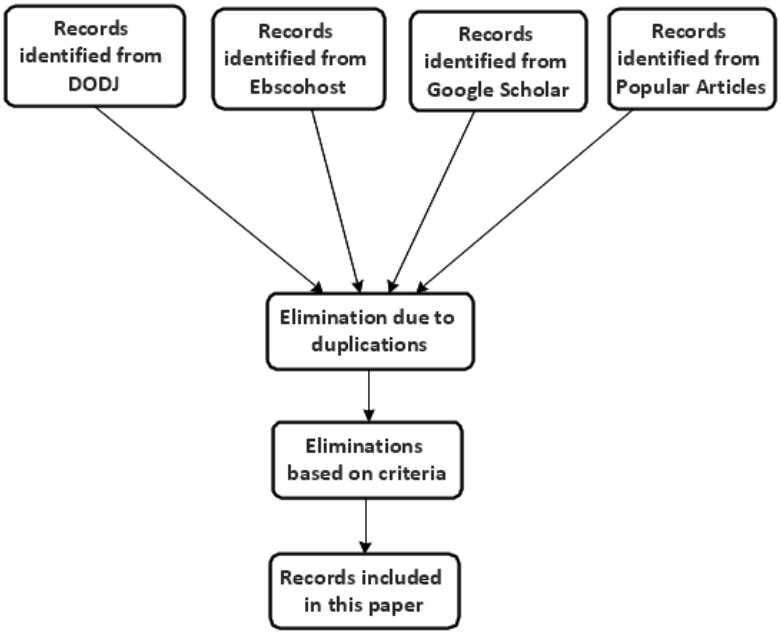

Fig.1. Search methodology carried out in this paper

III. RESULTS AND DISCUSSION

The keywords or query in searching are "mobile apps agriculture". Upon three databases that included this study, the highest results return by google scholar (>10,000), DOAJ (<20), and Ebscohost (<20). This reflectsa relatively small number of studies that focused on the availability and usability of mobile apps in agriculture. History shows that approximately ten years ago, some review papers focusing on mobile apps in agriculture has started to emerge. For example in the year 2011, this paper [1] highlighted the need for mobile apps in agriculture due to smallholder farmer systems show less productivity and profit than they could be. The offered solution was the embedded ICT in farming equipment and processes. Furthermore, the paper also suggested mobile agriculture initiatives as a solution to less farming productivity.

In the following year 2012, another paper [2] wrote about mobile applications for agriculture and rural development. The paper emphasized development impact, mobile ecosystem, and business model. The study included several important keys to today's farming industry such as sustainability, pricing models, and cost that lead to commercial and non-commercial mobile apps. The author summarized that better access toinformation anda better market that links for distribution network has produced higher income for the small farmer, lower distribution cost, and improve traceability and standards for buyers. It creates new opportunities for many parties whichare directly or indirectly related to the agribusiness.

Started in 2014, more review papers have exposed and started revealing the development process of mobile apps in agriculture. For example, [3] provided a review of the use of smartphones and its capabilities in agriculture. The scope was wider by mentioning the role of the agro portal (e-government) in supporting agribusiness. The paper reported that the previous agro portal system has been extended to mobile users especially Android users in additionto the usage of web-based and SMS systems in the daily operation. With this, the government information and services are easily accessed by the public using the recent advancements in mobile apps technology.

In 2016, some papers more concentrate on the mobile apps itself. For instance, [4] and [5] clearly stated a survey or study mobile apps or Android apps for agriculture. The paper written by Constantina Costopoulou, Maria Italiani, Sotiris Karetsos [4] underlined the heterogeneous and complex information in the farming industry. The key solutions offered were accessibility to the information, markets, and services. The study exposed the data collection in Greece about the farmers' and stakeholder interest and willingness to use mobile apps in agricultural activities. The result had shown the majority of them have never used mobile apps in their agricultural activities, back then. Hence the paper proposed the development of mobile apps for agriculture is deem important and required the active involvement of public agencies and ministry. Even the paper had to make a comparison between theamounts of mobile apps for health care in the year 2016 amounting to 259,000 apps against the agricultural apps amounting to 1.300 only.

In the same year 2016, a paper from India [5] reported on the information dissemination of the agricultural sector to the degree of knowledge-intensive that had been transformed into mobile apps for farmers. The background of the study was the high percentage of the Indian population (65%-70%) who is depending on agriculture for their living. The paper suggested that apps are supposed to be able to bridge the gap between agricultural input and delivery of agricultural outputs and infrastructure. Moreover, the paper also discussed emerging technology such as cloud computing, machine learning, and soft computing.

In the year 2018, [6] a paper focused on new terminology in farming called "precise agriculture". Precise or precision agriculture is defined as a new approach in farm management with the use of IT to ensure that crops and soil receive exactly what they need for better health and productivity. The primary goal of precise or precision agriculture is profitability, sustainability, and protection of the environment. The solution offered was a digital platform and digital ecosystem that involves smart systems such as AI, service-oriented architecture, ontology-driven knowledge-based, and multi-agent technology. The paper presented the results of their application in Moscow, the expected results, and future steps in agriculture.

In the year 2019 [7], this paper proposed apps supporting the sustainability of agricultural landscapes. The paper mentioned the importance of multi and interdisciplinary expertise to identify the righttools to link extension agents, farmers, and decision-makers. The authors highlighted that mobile apps that focus on these matters are still lacking and important to be developed soon. The following Figure 2 was included in the paper as a recommended software system design features meant for broadly applicable knowledge sharing systemsto improve the sustainability of agricultural landscapes.

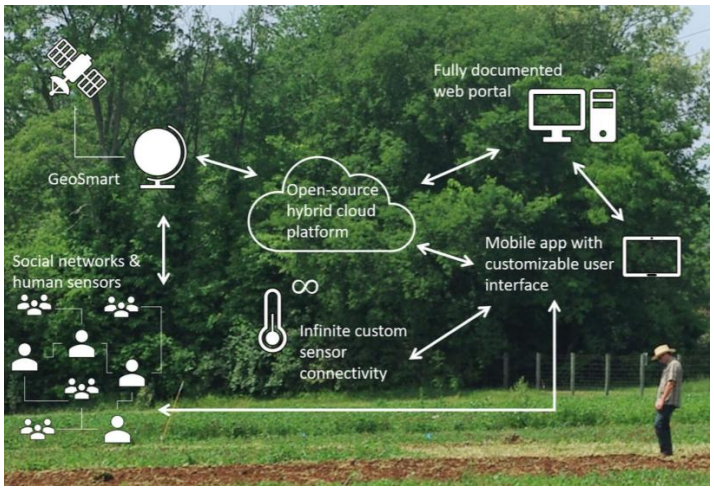

Fig. 2. Software System Design for Sustainable Agriculture [7]

In March year 2020, a paper [8] highlights the global trend in mobile apps for agricultural fields. The source for data collection was google play and windows phones in the years 2015 and 2018. The results had shown the largest number of agricultural apps i.e. USA, Brazil, and India. These results were generated from 843 apps survey that they conducted inclusive of 33 and 61 countries. The highest proprietary apps were found in the USA and Brazil. The study concluded that the global development of apps for agriculture is growing rapidly especially the ones without cost to users.

In the year 2020, there are numerous researches found in the literature related tomobile apps or ICT for agriculture. However, the ones which highlight the condition during coronavirus pandemic is extremely limited. We found this paper [9] highlighted specifically agri-information dissemination during the Covid19 lockdown in India. During the lockdown, farmers are unable to get the latest information about agriculture, especially about the market to reach users. Hence, mobile apps namely "Kisan Rath" were developed to facilitate transportation of food grains and perishables during the lockdown period in India. The mobile apps can help farmers and traders to connect with the transporters. There are more than 500,000 trucks and 20,000 tractors included in the network to support farmers with their products. With these apps, the farmers' product can move to warehouses, collection centers, or wholesalers. The mobile apps are developed in many languages including Hindi for farmers' ease.

Another paper in the year 2020 [10] has highlighted the impact of the Covid19 pandemic in the agriculture field in Bangladesh. This paper reported the use of the existing mobile apps in the country to minimize the disruption of agricultural services due to the Covid19 pandemic. This paper suggested parallel research to identify an effective pathway to enhance information flow and analysis. The output of this type of research will benefit the value chains in terms of efficiency and reliability. Apart from that, a paper [11] reported that in Africa, several actions have been taken to promote agricultural innovations and technologies during the Covid19 pandemic which one of them is mobile apps.

On the other hand, popular articles published for the general public have promoted mobile apps for farmers. Many short articles highlighted the name of the mobile apps that can be easily downloaded and used for the farmer to sustain their productivity. To name it a few, the best agricultural apps suggested by many articles are Agronote, AkerScout, Bushel, Crop Nutrient Advisor, and CropRecords. Due to language issues, these apps are popular in countries where English is widely spoken. The popular articles generally agreed that mobile apps for smallholder farmers should provide links for the farmers to reach products for farms operation, output markets, and distributors.

The following figureis presented in this paper to provide insights into agricultural apps. Figure 3 was taken from details provided in this paper [1] regarding the agricultural apps category that is usually needed by the farmer. We can see from the figure, the business and financial apps ranked higher in terms of use to support better productivity.

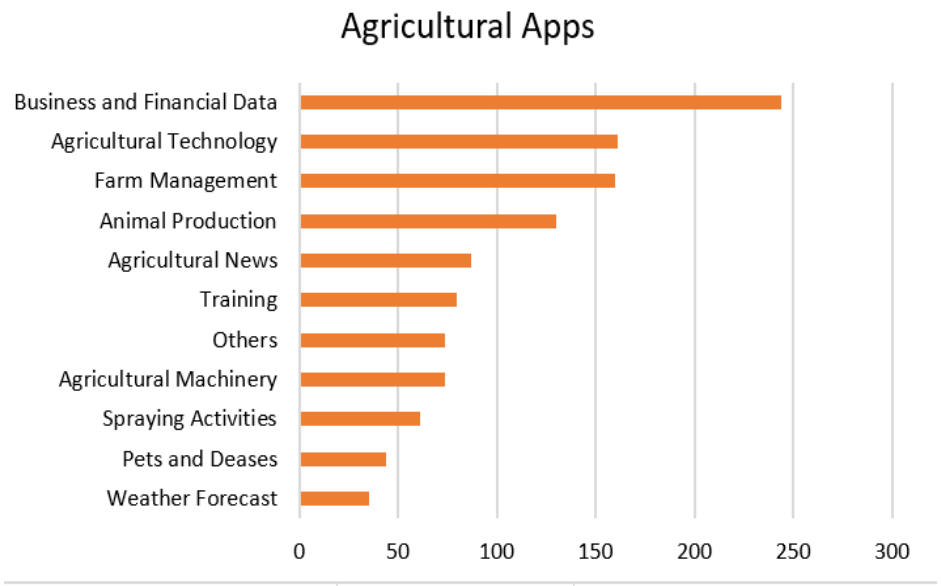

Fig. 3. Types of Agricultural Apps [1]

IV. CONCLUSION

The study under review shows that mobile apps indeed a global solution for farmers in many countries around the world. During the Covid19 pandemic, the mobile apps continuously supported farmers in many ways to ensure their productivity sustain and reach the market in time. Mobile apps have made farmers easier to search for agricultural-related information. It helps farmers in terms of productivity, market, and management decisions.

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"Lebak Lebung Auction" Fisheries Resources Management Based on Local Authority in South Sumatera"

"Lelang Lebak Lebung" is Local Wisdom –based Fisheries Resource Management in South Sumatera

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ABSTRACT

Lebak Lebung is a term used by the people of South Sumatera to refer to seasonally flooded waters or floodwaters. The term Lebak Lebung is only known in the area of South Sumatera. According to the scientific understanding of the meaning of Lebak Lebung swamp is a floodplain which is lowland on the banks of a river which is flooded when the river water disappears (during the rainy season). According to the data from The South Sumatera Marine and Fisheries Service (2015), the total inland waters of South Sumatera covering 2.5 million hectares and 43 % are in the form of Lebak Lebung swamps. The Lelang Lebak Lebung activity in managing fisheries resources is one of the ways to contain regulations that play an important role and aim to maintain the balance between fishing and the availability of fish resources to be captured so that the fish population can maintain its balance and sustainability

Keyword : *Balancing and sustainability, Lebak lebung, Local wisdom, Inland waters, floodplain,*

I. PRELIMINARY

1.1. Background

Most of the waters in South Sumatra consist of public waters. Public waters are parts of the surface of the earth that are permanently or periodically covered by surface water, both freshwater and brackish water, which are general (Gaffar, 2013).

The area of public waters in Indonesia, whether in the form of lakes, reservoirs, rivers, swamps, lebak and others reaches 55 million hectares during the rainy season or around 18 million hectares during the dry season. From these public waters, there are various types of fish of economically important value, both consumption and ornamental fish species. Public waters have become fishing grounds, both capture fisheries and fish farming.

According to data from the South Sumatra Maritime and Fisheries Service (2015), the area of South Sumatra's public waters reaches 2.5 million hectares, consisting of 43% lebak, large rivers and offspring 31%, lakes 11% and 15% swamps. The productivity of lebak swamp is quite high because of the high nutrient content derived from decomposition of decaying foliage. Lebak Lebung swamp waters can be used as a fishery business both for fishing and fish farming with a cage or pond system, especially in lebak swamp where the water is high enough and not dry in the dry season.

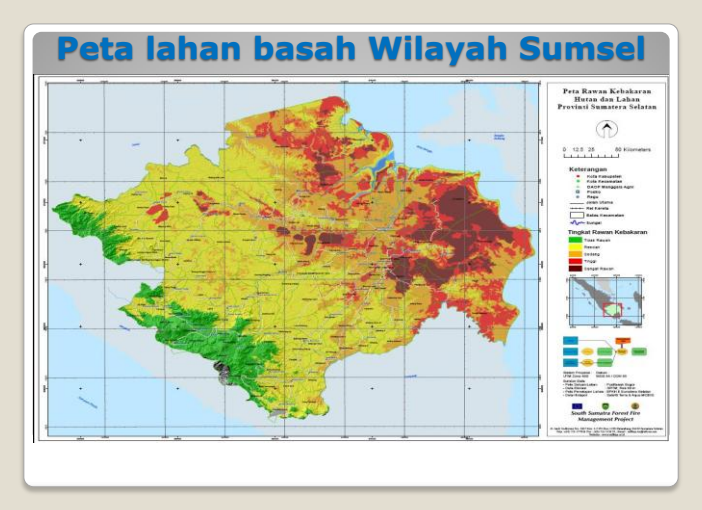

Figure 1. Map of lowland areas in South Sumatra Province

Considering that most of the areas in South Sumatra are lowlands (yellow in Figure 1) consisting of public waters, mainly in the form of lakes, reservoirs, rivers, lebak and flooded swamps, the role of waters as fish protein suppliers in South Sumatra has a function that very important because it involves the lives of many people. (Muslim, 2008), in South Sumatra public waters are not only used as a place to fish, but also as the main transportation that connects between regions. Here are some functions of public waters: as fish habitat, transportation facilities, sources of clean water for households and the fishing industry, sources of electricity, agricultural aeration and tourism.

Lebak Lebung area consists of lebak, lebung and river which are naturally in high tide season as a place for fish development and at low tide where people work on rice fields or for other agricultural purposes. Lebak lebung is a very fertile area because it contains many nutrients and also natural food for fish. Besides that, swamp lebak lebung is very important as a producer of freshwater fish (Samuel, Susilo and Zahri, 2002). These waters are classified as productive and can function as areas for food, spawning areas and nurseries for fish (Utomo and Ashari, 1999).

To maintain the preservation of fish catch resources, effective and integrated management of aquatic ecosystems is needed. One way of managing ecosystems that has long been applied in South Sumatra is the establishment of the Lebak Lebung auction area in river, lake, and swamp flood waters. Conservation of fish resources is an effort to protect, preserve and utilize fish resources, including ecosystems, species and genetics to guarantee, preserve the sustainability of their resources, availability and sustainability while maintaining and increasing the quality and diversity of fish resources (Government Regulation RI Number 60 of 2007).

Because the term Lebak Lebung is only known in the area of South Sumatra which is a local wisdom in the field of fisheries, the authors consider it important to raise this topic with the title "Lebak Lebung Auction" Management of Fisheries Based on South Sumatra Local Wisdom.

1.2. Purpose

The purpose of this article is to :

a. Understanding the meaning of Lebak Lebung

b. Understanding the ins and outs of the implementation of Lebak Lebung Auction activities in South Sumatra

c. Learn the advantages and disadvantages of Lebak Lebung Auction

d. Providing suggestions and opinions for the preservation of local wisdom in the Lebak Lebung auction in South Sumatra.

II. LITERATURE REVIEW

2.1. History of Lebak Lebung Auction

Lebak lebung is a term used by the people of South Sumatra to refer to seasonal inundated waters or flooded swamps. the term lebak lebung is only known in South Sumatra Province. According to the scientific understanding of lebak lebung swamp waters is a floodplain swamp waters (floodplain) is a low plain on the riverbank that is inundated when the river water overflows (during the rainy season). In South Sumatra Province, the potential of the Lebak Lebung swamp waters is quite large. According to data from the Office of Maritime Affairs and Fisheries of South Sumatra Province (2002), the area of South Sumatra's public waters is 2.5 million ha and 43% is in the form of swamp lung lebung.

Lebak Lebung auction is a system of control of public waters in South Sumatra, especially tributaries that are flooded swamp (lebak lebung). The control of waters by the Marga Government has been stated in the "Simboer Tjahaya Oendang-oendang". This law is the oldest law, which has been used since the seventeenth century in the area of Palembang Darusalam Kingdom.

The original text of this law was written in an ancient Arabic script, compiled and implemented around the year 1630, when the Kingdom of Palembang Darussalam was ruled by Queen Sinuhun Seding. Since the government of Sri Sultan Abdurrahman, the area of Palembang has expanded, this law has been amended and expanded with a regional law called the Sindang Merdika Law. Thus in accordance with developments, this Act was changed by the invaders and made into a customary law, no longer a constitution.

The Marga government has full authority over the people in its territory. The Marga government was led by a clan leader called Pasirah. Pasirah is a person that is highly respected by the people in Marganya.

The Dutch East Indies government at that time confirmed the custom of auctioning these waters with IGOP Stbl. 1919. No.814 (*Inlandsche Gementee Ordonantie Palembang*). Broadly speaking, the purpose of the auction lebak lebung is to:

1. Obtain finance for clan cash who need funds for construction and payment of salary officials.
2. Arranging fishing activities so there will be no struggle between the fishermen and illegal fishing.

Meanwhile fishing activities in the waters, including in the rivers continue. Then in 1973, the Regional Representative Council of the Province of South Sumatra (DPRD SUMSEL) established a Regional Regulation (Perda) TK I. South Sumatra Province No.

8 / PERDASS / 1973/1974 dated July 14, 1974 concerning the lebak lebung auction. This Perda in principle regulates the uniformity of regulations on the procedures for auctioning lebak lebung in clans in the Province of South Sumatra. The Perda was first changed to a Perda TK. I. South Sumatra Province No. 6 of 1978. This change in principle concerns changes in clan cash arrangements. The amendment is 70% for Kas Marga to become the TK.II Regional Government Cash concerned.

With the Republic of Indonesia Law No. 5 of 1979 concerning Village Government, the Marga Government system in the South Sumatra Region no longer exists. The clan government system was replaced by the Village Government system. Thus the Head of Clan (Pesirah) no longer has power over its people and also its natural resources (lebak lebung). But the Lebak Lebung auction system is still being continued based on the Decree (SK) of the Governor of KDH TK I South Sumatra on November 5, 1982 No. 705 / KPTS / II / 1982 concerning the delegation of authority to conduct lebak lebung auction to TK II Region in the Province of TK I South Sumatra Province. Then some TK II Regions made Regional Regulations (Perda) regarding the auction of lebak lebung in their respective regions. Musi Banyuasin (Muba) Regencies District Regional Regulation No. 09 of 1985, in Muara Enim Regencies Regulation No. 05 of 1987, in Ogan Komering Ilir (OKI) Regencies, Bylaw No. 28 of 1987. Now, each regency has changed the regional regulation several times regarding the auction of lebak lebung. The local regulation (Perda) of Ogan Komering Ilir (OKI) Regencies has been updated, namely Perda No. 8 of 2001 concerning lebak lebung auction in OKI Regencies.

2.2. The Process of Implementing Lebak Lebung Auctions

2.2.1. Auction object

The object of the auction is fish resources, namely all types of fish and other aquatic biota found in the lebak lebung and river areas, except for biota that is protected by statutory regulations. Determination

of the auction object is based on community proposals determined by the Regent's decree (SK) as the head of the region.

The object of auction can be in the form of lebak lebung, rivers and other waters. However, not all waters can be used as auction objects. The waters that cannot be auctioned include: (1) the main river that functions as a transportation route, (2) the coastal area as far as 4 nautical miles measured from the coastline to the high seas and / or towards archipelagic waters, (3) nyurung land, is an area when low-water land is contained in a river and when high water is submerged by river water, (4) a fishery reservoir / reserve contained in the Lebak or Lebak River.

Gambar 2. Lebak Lebung

2.2.2. Auction Committee

The composition of the auction committee consists of:

a. Person in charge : Regent

b. Auction Supervisor :

Chairman : regional Secretary

Secretary : Head of Village Administration Section

Member : 1. Head of Regency Fisheries Service

2. Head of Law and Organization

3. Head of Finance

4. Head of Revenue Service

c. The auctioneer :

Chairman : district chief

Secretary : district chief secretary

Recipient Treasurer : District staff appointed by the district chief and Legalized by Decree of the Regent as

Treasurer Receiver / Depositor

Member : Kpl District Fisheries Service Office

Kpl Desa appointed by the district chief

Other elements according to the designated needs district chief

2.2.3. Pengemin

A manager is an auction participant or person who wins an auction. If a participant gives the highest bid of an auction object, and the person can pay in cash at that time, then that person is called a manager.

2.2.3.1. Obligations and prohibitions of the developer

1. Every developer is not permitted to lead more than 3 (three) auction objects
2. Implement and comply with the instructions and technical guidance from the Fisheries Service
3. Using labor (fishermen) from the village around the auction object
4. At the end of the auction period that has been determined, the developer must return the waters of the auction object that was attempted to its original state
5. The craftsman are prohibited from inhibiting and endangering water traffic
6. The craftsman is prohibited from harming farmers when processing rice fields which are included in the lebak lebung area that is auctioned.
7. The craftsman is prohibited from reselling the management rights to third parties.
8. The craftsman prohibited from nesting in lebak that has been planted with rice and opening water dams used for irrigating rice fields.

2.2.3.2. The craftsman Rights Protection

1. Everybody is prohibited from catching, nesting, fishing, taking fish and other aquatic biota from auction objects that have been won by the developer without permission from the owner.
2. Exceptions to the above provisions are for the owners of rice fields whose rice fields are included in the Lebak Lebung area which is only a reasonable food necessity and is not for sale

2..2.4. Protection of rights and restrictions for rice field owners

1. Every one is not allowed to make artificial melting on land / rice fields which are included in the Lebak Lebung auction area, unless there is permission from the Regent
2. Lebung or river inheritance for ownership and inheritance must be authorized by the Regent and recorded in the auction Regester.
3. If in point 2 above a dispute occurs, the settlement is through the District Court (PN).
4. Against the melt or river or legacy legacy that already exists and belongs to the community, if the water is still in the right of the owner to take the fish but if the water has receded automatically becomes the owner with the obligation to contribute to the Regional Government adjusted to the extent.
5. Provisions regarding the amount of contributions referred to in item 4 shall be stipulated in a Decree of the Regent.
6. The craftsman is prohibited from destroying the rice that has been planted by the owner of the rice field / rice processor.
7. The craftsman is prohibited from nesting in paddy fields that have been planted with rice, except with permission or agreement from the owner / processor of the paddy fields.
8. The owner of a rice field who plants rice in his field which is auctioned must be within 3 meters of the lebak / lebung that is auctioned.
9. Natural Lebung which is found in paddy fields which is included in the Lebak Lebung auction object is absolutely the owner's right and the penginin is obliged to give rewards to the owner of the land / paddy by 35%.

2.2.5. Auction Implementation

1. Lebak Lebung auction is conducted by the auction committee on the same day.
2. If the auction is not appropriate on that day, it can be continued the next day.
3. The auction is conducted openly, directly in public with a gradual bidding system with a standard price set by the Regent, with the proposal of the sub-district head.
4. The committee did not accept a written offer.
5. The auction period is valid from January 1 to December 31 of the current year.
6. Before bidding on the auction object, the auction will first announce the number of auction objects to be auctioned and the number of eligible bidders and observers present.
7. For each auction object, the auctioneer must state the boundaries of the auction object area and the standard price.

8. If the provisions of points 1 to 4 above are not fulfilled, the auction is canceled.
9. Bidders who bid the highest pay cash in the form of cash at the auction price at the same time to the treasurer / recipient.
10. If the participant with the highest bid cannot pay cash at that time, the auction falls on the participant who bids at the second highest price and if the second bidder cannot pay cash at that time too, then the auction is canceled and repeated immediately.
11. For bidders who cannot pay the bid price (as in item 10), they will be fined 10% of the highest bid price and will not be allowed to participate in the bid object at the time of the re-bid.
12. If the highest bidder is deemed unfair by the bidding committee, the bidding committee may stop and cancel the bid for the auction object referred to by the tender supervisory committee.
13. Against auctioned objects that cannot be sold can be offered again for auction and if they are still unsold, they will be returned to the local Government C.q. District Fisheries Service.
14. The auction committee and auctioneer are not allowed to double as bidders.
15. Civil servants, TNI, POLRI, regional officials, village heads and village officials are prohibited from participating in bidders.
16. The auction committee announced back to the public the auction objects that had not been sold.
17. Re-auction for auction objects that have not been sold as referred to in item 13 shall be carried out in accordance with regional regulations.
18. The re-auction as referred to in item 16 shall be carried out no later than 30 days after the first auction.
19. If the provisions of items 17 and 18 are not fulfilled, the auction shall be declared null and void.

2.2.6. Distribution of Auction Results

The distribution of auction results is as follows:

a. 2% for the Camat as the chief executive in the subdistrict area
b. 3% for the village head in regency
c. 5% for village officials in the Regency
d. 5% for BPD (Village Representative Body) in the Regency
e. 2% for traditional stakeholders in the Regency
f. 4% for the District Fisheries Service to carry out technical and conservation guidance
g. 55% of the village treasury as Village Government revenue which is used for development costs
h. 24% for the regions.

From the results of the division it can be seen that the results of the Lebak Lebung Auction can increase the source of village income, in addition to increasing employment.

III. DISCUSSION

3.1. Judging from the Benefits of Lebak Lebung Auction

If seen from the benefits of the Lebak Lebung auction it is actually very noble, namely:

1. Get financial resources for the village treasury who need funds for construction and payment of village officials.
2. Arranging fishing activities so there will be no struggle between the fishermen, as well as
3. Reducing illegal fishing (illegal fishing), so that conservation of fishery resources can be maintained.

From the above objectives, it has been arranged for the use of natural resources economically and regulates their use for the benefit of many people and so that there is no destructive and excessive fishing (illegal fishing). But besides that the most important thing is the need to maintain a balance between the use of fish resources that can be done with the balance of natural abilities available for conservation purposes.

3.2. Judging from the Impact of the Lebak Lebung Auction

According to Nasution, Z (2008; 2012), regency regions that have lebak lebung land are Ogan Komering Ilir (OKI), Ogan Ilir (OI), Musi Banyuasin (MUBA), Banyuasin (BA) and Muara Enim (ME) Regencies. The auction in the five regencies each had different impacts, but in general there were positive and negative impacts. For the government generally a positive impact because the auction lebak lebung become a source of regional income (PAD), while for the community there are those who feel profitable (positive) and some who feel disadvantaged (negative).

3.2.1. Positive impact

a. With this auction system, it can increase the Regional Original Revenue (PAD).
b. Opening employment as fish processing entrepreneurs such as (salted fish, salai fish, fish and fish processed products such as fish crackers) and fish catchers.
c. Fostered communication and mutual cooperation between fishing fishermen.

3.2.2. Negative impact

a. Fishers / fish farmers whose capital level is low, receive less attention in protecting business opportunities. Those who win the auction are always people with strong capital while fishermen are on the weak side
b. There is always a prolonged conflict between the land owner and the owner, the land owner is no more than a spectator
c. The competition of the pengemin to win the auction which from year to year is increasing causing the preservation of fish resources from year to year seen a decline in public water areas
d. Catching tends to use large tools such as funnels, tuguk, kerakat, ponds, will endanger the preservation of fish resources
e. Pondok operational costs, fixed fishing gear (tuguk, funnel and etc.) quite high, 3-5 years durability. If the following year not win then the tool must be withdrawn.
f. The basic price of the auction based on the previous basic price (Regional Regulation of the OKI Regency in 2001) is less realistic and the condition of the waters (fish potential) is not always greater than the previous year.
g. The auction winner usually sells back to several fisherman cultivators so that the price is cumulatively more expensive than the original price
h. Obligations to clear waters are almost said to be of no concern
i. With the cultivation of lebak lebung by pengemin, opportunities for the community to develop fish culture will be hampered, making land optimization difficult.
j. The social gap between the leader / owner of the strong capital and the fishermen whose condition does not change, will often cause social unrest and intrigue in the community and this must be watched out for.
k. Small fishermen in carrying out fishing activities are very dependent on the rules made by the auction winner, for example : the price of fish is determined by the winner of the auction, and must be sold to the winner of the auction, the fishing area is restricted, the fishing community even though it has long lived in these waters if violating the rules will still be driven out.
l. Beach and bad land areas being auctioned are against the TK.I Regional Regulations. South Sumatra No. 18 of 1984 article 13 (coastal waters are prohibited from being auctioned)
m. The closure of fish migration from one location to another, this disrupts fish breeding
n. Disturbing the reservoir on the deep lebak because it also took part in the auction
o. The principle of ownership belongs to the government. Optimal utilization of fish resources from Lebak Lebung does not go to the people who have the right to use Lebak Lebung, but the right to enjoy monopoly profits for one party.

3.3. Some Notes for Repairing Lebak Lebung Auctions

1. From the negative impacts arising from the Lebak Lebung Auction, there are a number of records that can be put forward regarding the implementation of the lebak lebung auction in South Sumatra, for future improvements, including: Local fishermen and / or farmers in lebak lebung auction often cannot become 'masters in their own land". In the future the winner of the Lebak Lebung auction should be prioritized for farmers / fishermen groups in the region, so as not to cause social jealousy between farmers / fishermen and strong capital owners.
2. Difficulties in the process of disbursing funds from banks to farmers / fishermen groups due to classical obstacles (low quality human resources and weak business management, lack of collateral, high-risk fishing businesses and lack of concrete guarantees of marketing results). For this reason, the role of the Government Bank in disbursing the People's Business Credit must be maximized and the requirements are not complicated.
3. The working group formed each time the auction is temporary. Because of that the relationship between the pacher or pengemin with the ax occurs every time the auction. Thus it is assumed that the "inner connection" in the working relationship is loose. Whereas groups that remain with a tight working relationship will be the basis for the formation of fishermen groups that can be developed into cooperative institutions, which will formally be able to open up opportunities for working capital.
4. The auction validity period is only one year and there is no certainty for the following year. This can trigger a weak sense of ownership that will reflect how much responsibility for the preservation of fisheries resources in the area. Therefore the proposed validity period can be 2-3 years.
5. The auction winner often resells the land he has won at a higher price. So there are indications he took part in the auction just to take advantage only. Going forward the rules must be tightened, if it is found out that the winner of the auction resells the land, then the results of the auction can be canceled and the management transferred by another party.
6. Land that has been won does not need to be limited / closed in such a way that it does not interfere with fish migration from one location to another and does not interfere with fish breeding.
7. Because the focus of the auction is to achieve regional income, while the rules regarding the preservation of fish resources are even almost ignored. This condition must be immediately corrected, namely by strengthening regulations and raising the awareness of all parties so that the function of the river can be achieved to the fullest, while still paying attention to its balance and sustainability.
8. Often reservoirs in the deep lebak also participate in auctions, so that the fish resource ecosystem and the environment are also disrupted. This should not happen, there needs to be an awareness of all parties to maintain the diversity of genetic resources (germplasm) and preserve the use of species and ecosystems.

3.4. Steps to Ensure Sustainability of Aquatic Resources

In order to guarantee the preservation of water resources (economic and ecological value), the following areas need to be considered for the following lebak lebung auctions:

1. Bidders are people who are responsible for the utilization of water resources, that is, responsible for economic and ecological sustainability.
2. It needs to be activated by the institution/service in charge of evaluating the stock/population potential
3. It is necessary to consider the management of fish resources in an integrated and community-based manner by forming fishermen groups.
4. The concern of the auction winners to the preservation of fish resources so that the population is sustainable by using selective fishing gear and providing an asylum/reservoir area.
5. The auction is not held once a year, given the high cost of fishing gear, so the manager does not drain the available fish resources. Must pay attention to sustainability for their children and grandchildren.

6. Reserves do not participate in the auction.

With the steps above, it is hoped that the balance and sustainability of fisheries resources can be maintained for the continuation of our children's generations.

IV. CONCLUSION

From the results of the previous discussion it can be concluded as follows:

1. Lebak Lebung auction is one of the local wisdoms of fisheries management in South Sumatra.
2. Lebak Lebung Auction Activities in managing fisheries resources is one of the methods that contain regulations that play a very important role and aims to maintain a balance between fishing and the availability of fish resources to be captured, so that the fish population can be maintained in balance and sustainability.
3. In the field implementation, Lebak Lebung Auction activities have both positive and negative impacts. The positive impacts need to be preserved continuously and the negative impacts need to be evaluated for improvements

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Determination of the Field Sprayers and Their Problems in Thrace Region,Turkey

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ABSTRACT

Chemicals are widely used in crop protection around the world. Field sprayers commonly used to apply pesticides on the field crops. The area covers Tekirdag, Kirklareli, Edirne and the parts of Istanbul and Canakkale provinces which are in the European continent called Thrace region in Turkey. Since the main crops grown in Thrace are grains and industrial crops, field sprayers are the most common equipment for crop protection. Research is conducted in order to determine the field sprayer properties and the problems faced while operating them. A survey is carried out by interviewing 132 farmers with 22 questions. The results show that 97.7% of the farmers grow wheat and 92.4% of them grow sunflower. Farmers who have field sizes between 10-50 hectares are 46.2 % of the total participants. The most preferred sprayer brand is Parlayan Co. and commonly used spraying nozzles are domestic nozzles. The commonly used field sprayers have 800-1000 l tank capacity, 12 meter of boom width, and a manual boom folding mechanism. 23.5 % of the farmers have experienced cracks on the mainframe of the sprayer, 57.6 % of them have stated that the sprayer booms have been fractured by hitting the ground or an obstacle. 18.9 % of the farmers have complained about the pressure changes on the pump, 78.8 % of the sprayers have had nozzle clogging issues and 20.5 % of the farmers stated that they have seen cracks on the liquid tanks in time.

Keywords*—field sprayer; pesticide,Thrace, boom, nozzle, failure*

I. INTRODUCTION

Farmers have to handle the threats to crop health in order to get maximum yields from the field. Different methods are used to protect the crops from diseases or other factors that are potentially damaging. The most common and efficient method is chemical crop protection. Most of the fungal diseases, weeds, insects, and other microorganisms which are able to damage the crop and reduce the yield can be eliminated using proper chemical compounds.

Since the crop production increases in Turkey, new kinds of pests arise and the existing pests gain immunity to the active ingredient, pesticide use is increasing year by year, as well as all over the world. Annual pesticide usage in the world is 2 million tones and it is estimated to reach 3.5 million tones after 2020 [1]. According to data from the year 2018, 60000 tonespesticides were used in Turkey [2].

Pesticides are applied with a different type of equipment depending on the size of the field, type of the field, intended purpose, and plant species. The most common equipment used for pesticide application in Turkey is a field sprayer.

The area that covers Tekirdag, Kirklareli, Edirne provinces, and the parts which are in the European continent of Istanbul and Canakkale provinces is called the Thrace region. Thanks to the diversity of the climate in Thrace, crop diversity is great as well. Grain, industrial crops, feed crops, rice, sugar beet, olive, grape are commonly grown in that region. Since the field crops are widely spread over the

region, field sprayers are commonly used in Thrace. With the help of the humidity, temperature, and rain, field crops tend to be damaged by fungal diseases, pests, and weeds. Thus, Thrace farmers apply pesticides so often to protect their crops from diseases, which makes the field sprayers rather precious in their machinery.

As the field sprayers are crucial equipment in Thrace, the design characteristics have to be adapted to these conditions. Thus, sprayer manufacturers have tried to design sprayers that are easy to use, durable, and can be used for many years. Notwithstanding the strong and stable design of the sprayers, the defects and failures occur in field conditions that can be named as user experience which need to be taken into account by manufacturers.

Several researches are conducted about sprayers and their conditions in Turkey on both national and regional basis. Demir and Celenhave researched the problems and conditions of the sprayers in Tekirdag province [3]. The authors surveyed 718 farmers and investigated their sprayers. They concluded that 72.28 % of the sprayers were field sprayers. Moreover, 65 % of them have leakage and 28 % of them have nozzle clogging problems.

Baran and Durguthave investigated the agricultural mechanization of the West Marmara Region between 2004 and 2013. They stated that the number of sprayers increased by 19.75 % in ten years [4].

Bayat and Itmec have researched sprayer manufacturers. They interviewed 19 manufacturers from 9 different provinces and investigated the failures on the sprayers. Authors have stated that 78 % of the failures of the sprayers were pump based. Also, 78.95 % of the sprayers had boom defects and fractures, 36.84 % of them had defects on the chassis, 36.84 % of them had nozzle clogging. Furthermore, the sprayers have problems with the filter system, hoses, pipes, regulators, and valves [5].

Temel and Oztekin have investigated the crop protection equipment in terms of work safety. They have surveyed the farmers in Tokat province. The authors concluded that 76.8 % of the farmers had an intermediate level of knowledge on crop protection equipment, 42.8 % of them have never adjusted the parameters such as pressure, flow rate, and operation speed of the sprayers. Moreover, 42.1 % of the farmers have never made an adjustment or maintenance on the sprayers[6].

This research is aimed to survey the farmers in the Thrace region of Turkey, where the field crops are commonly grown and field sprayers are mainly used. In order to advise and influence the sprayer manufacturers, the field sprayers are investigated from the farmers' aspect.

II. MATERIALS AND METHODS

A survey with 22 questions with 2 sections for the farmers from the Thrace region was created. 132 farmers are interviewed and asked to answer the survey questions. 49.2 % of the farmers have fields in Tekirdag province, 22.7 % of them are from Edirne Province, 18.2 % of them are from Kırklareli province, 5.3 % of them have fields in the European side of Istanbul and 4.5 % of them are from Canakkale. The reason why the number of farmers has fields in Tekirdag province is the crop diversity thanks to the climate and landscape characteristics.

In the first section of the survey, farmers' location, field size, crop types, tractor horsepower, the brand of the sprayer, tank capacity, age of the sprayers, working width, nozzle characteristics, folding mechanism are asked. In the second section, the problems and challenges experienced by farmers while they were using the sprayers and how to solve them are asked. Furthermore, farmers are asked whether they create tramlines while drilling, how the sprayer boom behaves while operating, and what they have been doing to prevent overlapping in geometrically uneven fields.

The survey consists of simple, understandable questions and terms in colloquial language. It is both published and shared on the internet and social media and directly asked the farmers by visiting randomly selected farms, villages, or cities.

III. RESULTS

The most common crop grown by farmers is wheat. 97.7 % of the farmers stated that they grow wheat. The second most common crop is the sunflower, which grew by 92.4 % of the farmers who participated in the research. As the Thrace region meets 80 % of the sunflower production in Turkey [7], that rate is not surprising. Also, 49.2 % of the participant farmers grow rapeseed, 53 % of them grow barley, 24.2 % of them grow corn and 12.9 % of them grow rice. In addition to these, there is one each farmer who grows oat, watermelon, birdseed, ryegrass, tomatoes, zucchini, pepper, grape, chickpea, and feed crops.

Regarding field size, 46.2 % of the farmers have a total production area between 10-50 hectares. 18.9 % of them have less than 10 hectares. The percentage of farmers who have a production area from 50 to 100 hectares is 16.7 %. Farmers who have 150 hectares and bigger area are 9.1 % of total participants. In addition, 62.9 % of them make tramlines while drilling, and the rest of them create tramlines in the first pesticide application after the germination of the crop.

The most preferred sprayer brand is Parlayan Co. 28 % of the farmers claimed that they use sprayers of that company. The other brands preferred are Onallar Co. as 13.6 %, Taral Co. as 12.9 %, and Zirmak Co. as 9.9 %. Also, 2.3 % of the farmers do not know the brand of their sprayers. All brands used by participant farmers are shown in Fig. 1.

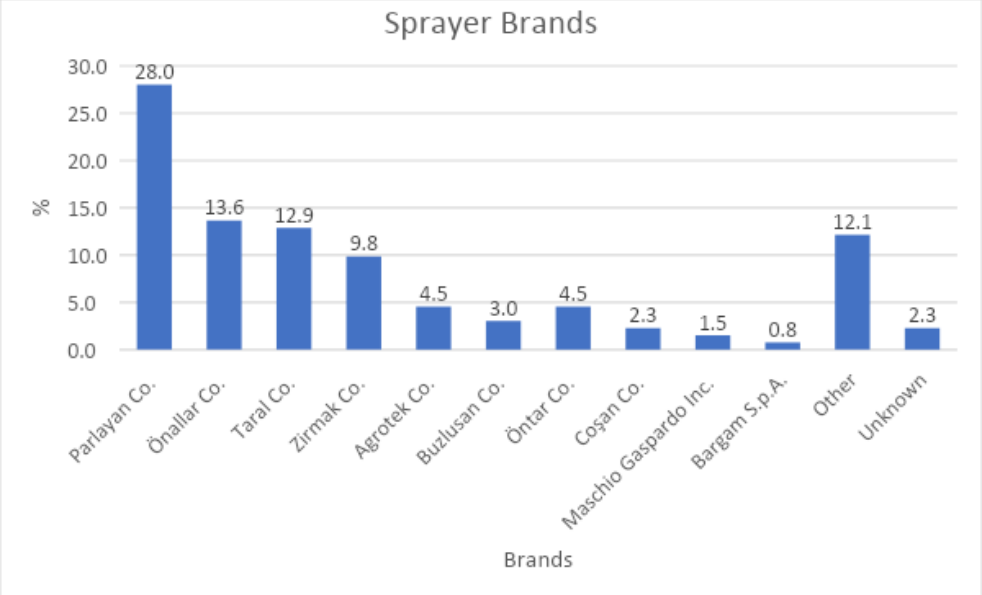

Fig. 1. Sprayer brands used by participant farmers

The engine power range of the farmers' tractor which is used with sprayers is asked. 32.6 % of them have answered that they use tractors with 100-110 HP range. 23.5 % of them are in the 90-100 HP range, 24.2 % of them are in the 70-90 HP range. The farmers who have a tractor with an engine power less than 70 HP are 11.4 % of total participants. 8.3 % of the farmers have answered that they attach their sprayers on the tractor with an engine power of more than 110 HP.

Regarding the tank capacity of the sprayers investigated in the research, 32.6 % of them have 1000 lt capacity, 34.8 % of them have 800 lt capacity, 21.2 % of them have 600 lt capacity, 7.6 % of them have a capacity less than 400 lt and 3.8 % of them have capacity more than 1200 lt.

46.2 % of the sprayers have 12 meter booms, 39.4 % of the sprayers have 15 meter booms, 11.4 % of them have 10 meter booms and 1.6 % of them have booms wider than 18 meter. 1 farmer stated that he/she uses an orchard sprayer. Moreover, 52.3 % of the sprayers are 1-5 years old, 20.5 % of

them are 5-10 years old, 18.9 % of them are older than 10 and 8.3 % of them are bought one year ago or less.

The distribution of the tractor power range, tank capacity, boom width, and age of the sprayers are shown in Fig. 2.

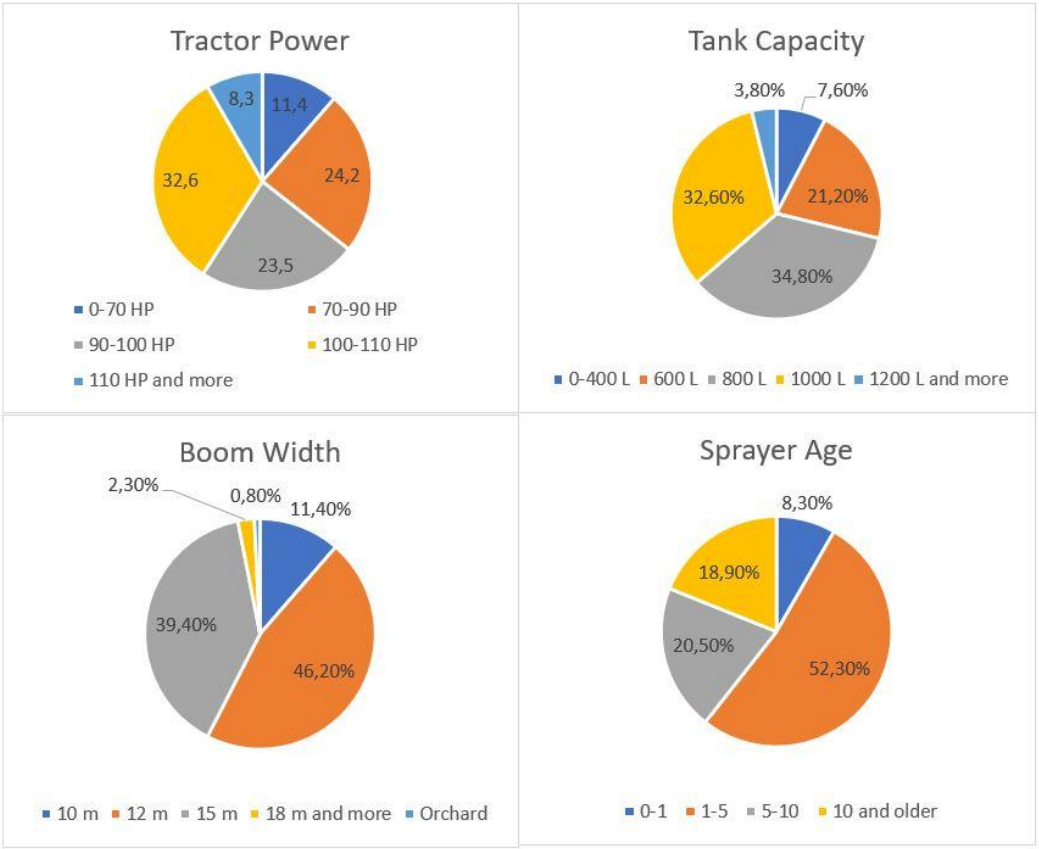

Fig. 2. The distribution of the tractor power range, tank capacity, boom width and sprayer age.

71.2 % of the sprayer have a manual boom folding mechanism and 27.3 % of them can be folded with the help of hydraulic power. One of the farmers stated that he/she had an electrical powered folding mechanism. Moreover, 87.1% of the sprayers fold horizontally and 12.9 % of them fold vertically.

Several nozzle brands are preferred among the farmers. Hence, 47.7 % of them claimed that they bought the nozzles made in Turkey. Also, 22.7 % of them use nozzles produced by Spraying Systems Co., 17.4 % of them use spraying nozzles of Lechler Co. 2.7 % of them use nozzles of AragSrl and 2.7 % of them use nozzles of Taral. 69.7 % of the nozzles have 3 mm orifice, 28% of them have 4 mm orifice. 15.9 % of them have 2 mm orifice and 3.8 % of them have 5 mm orifice. However, 11.4 % of the farmers do not know which spraying nozzles they use.

The failures on the sprayers experienced by the farmers during the pesticide applications are investigated on the main parts basis. Therefore, the problems on the boom, spray tank, mainframe, pump, and nozzles are determined.The participants stated that they have faced several failures on the sprayer frame. 23.5 % of the sprayers have cracks on the frame, %15.2 of the sprayers' frames were fractured due to the weight of the liquid tank and boom. Complaints regarding the overweight of the frame are also no ignorable. 20.5 % of the farmers stated the mainframe of their sprayers is rather heavy which puts too much load on the three-point linkage of the tractors.

The farmers are asked to claim the problems experienced with the sprayer booms. 57.6 % of them answered that booms are fractured due to the crash into the ground or an obstacle. Fracture on the

welding points is %18.2 and 6.1 % have fractures on the bolt joints. 22.7% of the sprayers have buckling and 18.9 % of them have fractures due to the vibration and uneven ground. 15.2 % of the farmers stated that booms are rather heavy and 10.6 % of the farmers claimed that the folding mechanism of the booms is not working properly. Moreover, 73.4% of the farmers complain about the vertical movement which causes uneven boom height.

The most common problem in the pump and filter systems of the sprayers are pressure changes. The percentage of farmers who have been challenged with pressure changes is 18.9%. Moreover, 16.7% of the sprayers have water leakage from the pumps 17.4% of the sprayers have oil leakage, 14.4% of the sprayers have defects on the diaphragm of the pumps, and 8.3 % of the sprayers have cracks on the body of their pump.

The percentage of the farmers who stated that the spraying nozzles of their sprayers clogged at least once is 78.8%. Besides, 17.4 % of the farmers claimed that the spray nozzles wear so often and 17.4 % of the farmers have experienced uneven spraying of the nozzles.

Cracks occurred on the liquid tanks during their operating time. 20.5 % of the farmers have complained about the cracks on the tanks. Also, 8.3% of the farmers were not satisfied with the filler cap. It is said that the place of the filler cap is nearly unreachable and has leakage when the tank is full.

The farmers have several solutions for those failures. While 49.2 % of the farmers take the sprayer to the nearest authorized service shop for repairment, 41.7 % of them repair the sprayers by themselves. The farmers' solution to the overlapping in the geometrically shapeless differs. While 71.2 % of them close the valves on the potentially overlapping side of the boom, 29.5 % of the farmers do nothing to prevent overlapping.

IV. CONCLUSION

In this research, Thrace region of Turkey is chosen and 132 farmers are interviewed with a survey consisting of 22 questions to determine their field size, tractor and sprayer properties, and the problems experienced during the spraying applications.

The majority of the farmers have crop production areas between 10-50 ha which is average in the Thrace region. The most common tractor power range is 100-110 HP. Since the percentage of the farmers who have a sprayer with 800 and 1000 l tank capacity is 67.4 %, it is not efficient to attach these sprayers to the tractors that have less engine power than 100-110 HP. Moreover, the most common boom width is 12 meter.

Since 60.6 % of the sprayers are between the age of 0 and 5, the majority of the sprayers can be considered new. Also, the most popular sprayer brand is Parlayan Co. The majority of the farmers prefer spraying nozzles made in Turkey. This can be related to the high exchange rates causing an increase in the price of the imported nozzles.

The farmers have faced several problems with the main parts of their sprayers. 23.5 % of the farmers have seen cracks on the mainframe, 57.6 % of them have reported that the booms are fractured by hitting on the ground or an obstacle, 18.9% of them have faced pressure changes during the application, 78.8 % of the farmers have had nozzle clogging and 20.5 % of them have seen cracks on the liquid tank.

While 49.2 % of the farmers have taken their sprayers to the nearest workshops to repair, 41.7% of them have solved the problems by themselves. This shows that the farmers know the maintenance, settings, and repair of their sprayers. However, 11.4 % of the farmers do not know the brand of the spraying nozzles on the sprayer and 2.3 % of them do not know the brand of their sprayers. The reason for that is misinformation about the nozzles and the sprayer while the farmer negotiates with the dealer and skips reading the manual of the sprayer.

To conclude, several problems can occur on the field sprayer in the progress of time. While some of them are design and manufacturing-based, problems can occur because of user error. Sprayer manufacturers need to determine those problems and develop durable and reliable sprayers to meet the farmers' expectations.

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Assessment of Above Ground Biomass in Phu Pha Wua Forest Park Kalasin Province, Thailand

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ABSTRACT

The above ground biomass (AGB) represent the living biomass and the sustaining of the forest. The objectives of this research to assess the AGB with measurements from the sampling plot using an allometric equation. In addition, to estimate the AGB with measurement and the satellite image data by using multi linear regression analysis. The independent variable of the satellite image used the normalized difference vegetation index (NDVI), soil-adjusted vegetation index (SAVI), and fractional vegetation cover (FVC). The results of the allometric equation calculated the AGB of the tree in the 62 sample plot was 79.6 Ton per hectare. The results of estimated the AGB found that the equation was y = (11705.07 * SAVI) + (-12925.7 * FVC), which the coefficients of determine R^2 was 0.85. The results estimated the AGB was 1055540.80 tCO2e in the study area.

Keywords— *above ground biomass; vegetation indices; multi linear regression model;*

I. INTRODUCTION

Carbon sequestration is the process for capture and storage the carbon from the atmosphere. This process can be storage and changing carbon stock in forest or agricultural is effect to amount of the emission or absorption of carbon dioxide CO2 in the atmosphere. The emission reduction of greenhouse gas (GHG) in the atmosphere is called for in Kyoto Protocol [1]. In Thailand, it recognizes the importance of solving global warming problems from climate change. By promoting projects that can help reduce GHG emissions according to a clean development mechanism. The Thai Cabinet's resolution approved the establishment of the Greenhouse Gas Management Organization as public organization in accordance with the law on public organization on May 15, 2007, the public organization entitled "Thailand Greenhouse Gas Management (Public Organization)", called "TGO" [2]. The TGO has organized to monitor and evaluate the certified projects. The objective of TGO to promote project development and the marketing certified GHG is the information center about the GHG operation situation.

This article focuses on the estimate of carbon sequestration in term of above-ground biomass (AGB). The AGB carbon pool consists of all living vegetation above the soil, inclusive of stems, stumps, branches, bark, seeds and foliage. The biomass of a tree is the sum of the biomass of its roots, trunk, branches, leaves and reproductive organs- flowers and fruits [3]. The different approached for assessment of carbon sequestration based on field measurement, remote sensing and geographical information systems (GIS) have been applied for AGB estimation [4]. Remote sensing has enabled us to monitor natural resources on a continental, even on a global scale. It is also the only realistic and cost-effective way of acquiring data over a large area [5]. Also, [4,5] they are presented the summary of the techniques for above-ground biomass estimation based on the remote sensing method from high, medium and coarse resolution data.

The main objective focused on the spatial regression model to estimate AGB according to the parameters derived from the remote sensing imagery. The parameters are based on vegetation indices including NDVI, soil-adjusted vegetation index (SAVI), and fractional vegetation cover (FVC) from the remote sensing imagery. The multi-linear regression model to estimate AGB with the vegetation indices.

II. MATERIAL AND METHODS

A. Study area and data collection

1)Study area

The study was implementation in PhuPhaWua Forest Park, Kalasin province, Thailand shown in fig 1. The study area (16.534385 N, 104.189437 E) covers approximately 7.84 sq.km.

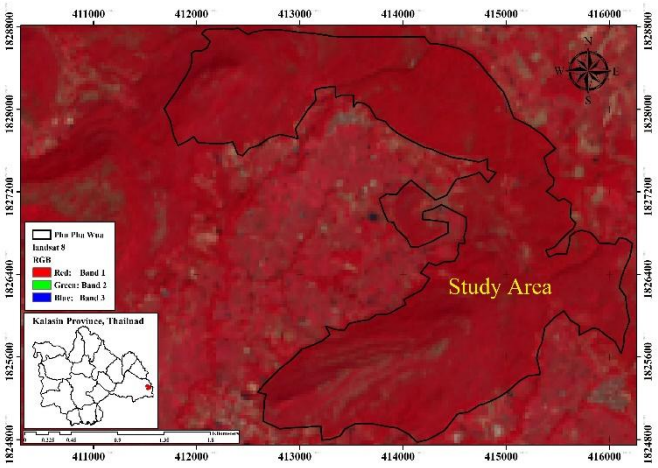

Fig 1. The study area, PhuPhaWua Forest Park, KalasinProvince, Thailand.

2) Data collection

The study site is located in PhuPhaWua Forest Park, Kalasin province, Thailand which containing various forest types. The sampling plot was the enumeration of randomly sample plots using the stratified random method. The number of permanent sampling plots in the sample tree is a total of 62 plots, by each plot has a dimension of 40 m. × 40 m. and all of the trees in the plot are measuring heights of trees at 1.30 meters and recording names, sizes, and heights of trees [6].

B. Above-ground biomass (AGB) from field survey

The analysis of above ground biomass of trees had used the allometric equation developed for local plants in Thailand [7]. The method was used to estimate the above ground carbon capture as shown in the equation [8].

$$W_s = 0.396(D^2H)^{0.933}$$
$$W_b = 0.349(D^2H)^{1.030}$$
$$W_l = (28/(W_s + W_b + 0.025))^{-1}$$
$$W_t = W_s + W_b + W_l$$

Where

W_t is the total of tree (kg);
W_s is the weight of the stem (kg);
W_b is the weight of branches (kg);
W_l is the weight of leaves (kg);
D is the diameter at breast height (cm);
H is the tree height (m).

C. Spatial analysis of AGB base on statistical regression model

The remote sensing data with the estimated AGB was based on field measurements from the survey sampling plots. The spectral information from the image can be approximated by the AGB by using the spatial analysis based on the regression model. This research focused on vegetation indices and fractional vegetation cover (FVC) for the estimated AGB base on the statistical regression model.

1) Vegetation Indices

The normalized difference vegetation index (NDVI) and the soil-adjusted vegetation index (SAVI) was used to improve the ability to separate healthy vegetation from other land cover types. In their original equations, they provide normalized values in the interval from −1 to 1. These vegetation indices have the advantage of being less dependent on illumination and having a good discrimination between different land cover types. They show higher values for vegetation, positive low values for water and bare soils and negative index values for clouds. The NDVI is a normalized ratio of NIR (near infrared) and Red (red band) defined as [9]:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

The SAVI was developed as a modification of the NDVI defined as [10]. The structured of the SAVI similar to the NDVI which includes a correctio factor of the near infrared band (L) [11] following:

$$SAVI = \left[\frac{NIR - Red}{NIR + Red + L}\right](1 + L)$$

Where

NIR is the near infrared band;
Red is the red band;
L is the soil brightness correction factor being equal 0.5;

2) Fractional vegetation cover (FVC)

FVC has been traditionally estimated from remote sensing data using empirical relations with vegetation indices [12,13] defined as:

$$FVC = \frac{NDVI - NDVI_s}{NDVI_v - NDVI_s}$$

Where $NDVI_v$ correspond to representative values of $NDVI_{max}$;
$NDVI_s$ correspond to representative values of $NDVI_{min}$;

3) Statistical regression model

A model for identifies the relationship between a dependent variable and independent variables is namely the regression analysis. A model can be solving the hypothesized, and estimates of the parameter values are used to develop many models for estimated regression equation [14-16]. In this study, the NDVI, SAVI, and FVC were defined as independent variables, and ABG was defined as the dependent variable. The multi-linear regression model equation defines as:

$$Y = a + bX_1 + cX_2 + dX_3 + \ldots$$

Where

Y defines the dependent variable;
X_1, X_2 and X_3 define independent variables;
a, b, c, d define constants.

III. Results and Discussion

A. Estimation of carbon sequestration from field survey

Total carbon storage of forest ecosystem in study area calculated through allometric equations. The allometric equation for estimation between the various parameter such as the diameter at breast height, the height of the tree, total height of the tree, the weight of the stem, the weight of branches, and the weight of leaves. The results of the data collected from the field surveyed sample plot and the allometric equation were applied to field measurements to estimate the AGB of the tree for the sample plot. The results found that the total number of 4682 trees in the 62 sample plots and the calculated the AGB of the tree in the sample plot using the allometric equation was 79.6 Ton per hectare.

B. The results of spatial analysis of AGB base on statistical regression model

Multiple linear regression analysis has been used for the estimation of AGB with the Sentinel-2 image variable, including NDVI, SAVI, and FVC to calculated the potential variable of AGB estimation. The results of the relationship between the independent variable with the linear regression model and the multi linear regression model following:

1) Spatial analysis of AGB base on statistical regression model

The results of the linear regression model between the AGB values from the data measurement with 62 sampling plots with the NDVI. The regression equation for estimated of the AGB value using vegetation indices, the linear regression equation is:

$$y=537.589*NDVI$$

The value indicates that R^2 = 0.86 of the coefficients of determine. The results of the analysis shown in Fig 2.

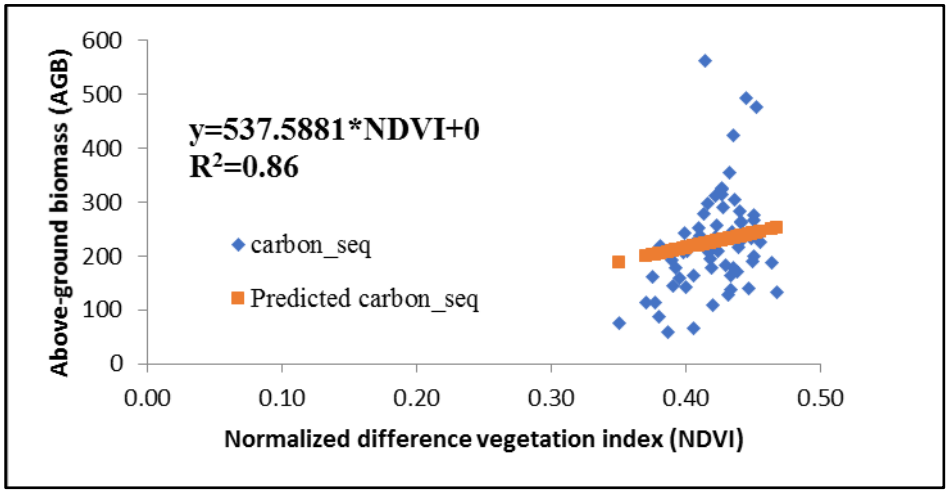

Fig 2. Regression coefficient between the AGB values and NDVI

The results of the linear regression model between the AGB values from the data measurement with 62 sampling plots with the SAVI. The regression equation for estimated of the AGB value using vegetation indices, the linear regression equation is:

$$y=358.40*SAVI$$

The value indicates that R^2 = 0.86 of the coefficients of determine. The results of the analysis shown in Fig 3.

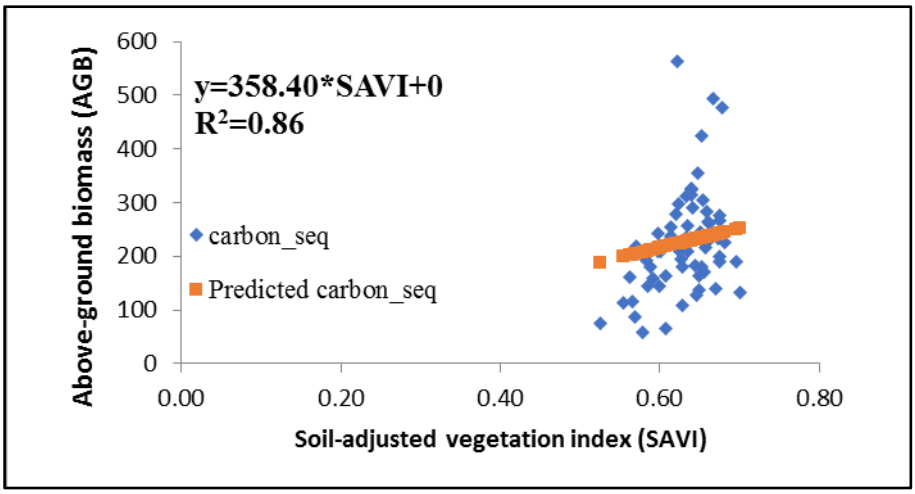

Fig3. Regression coefficient between the AGB values and SAVI

The results of the linear regression model between the AGB values from the data measurement with 62 sampling plots with the FVC. The regression equation for estimated of the AGB value using vegetation indices, the linear regression equation is:

$$y=358.40*FVC+0$$

The value indicates that R^2 = 0.85 of the coefficients of determine. The results of the analysis shown in Fig 4.

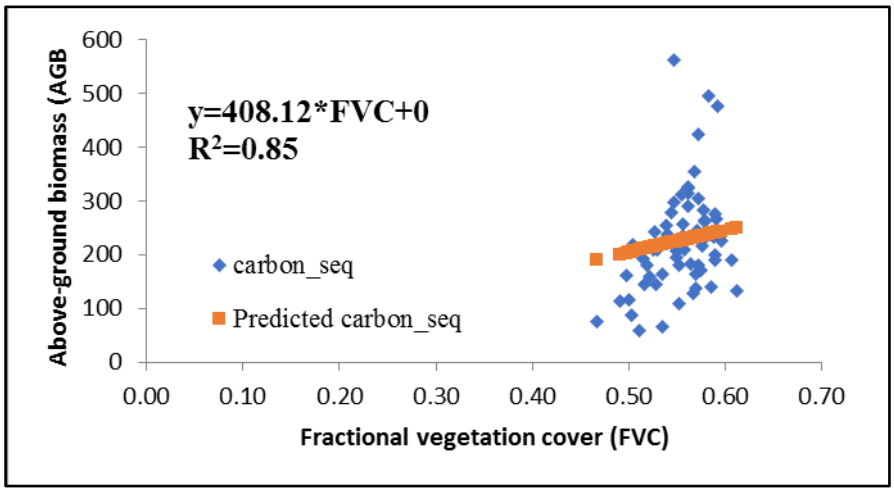

Fig 4. Regression coefficient between the AGB values and SAVI

2) The relationship of linear regression model with the satellite image variable

A multiple linear regression analysis was conducted with 62 sampling plots was observed that the vegetation indices variables including NDVI, SAVI and FVC, were significant at the 95% confidence level. The results show that the multi linear regression equation for estimated of the AGB value using vegetation indices, the multi linear regression equation is:

$$y = (11705.07 * SAVI) + (-12925.7 * FVC)$$

The value indicates that R^2 = 0.85 of the coefficients of determine. The results of the analysis of the variance in the model show in Table 1.

Table 1 ANOVA table of the multi linear regression model.

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	3216200.36	1072066.79	193.266197	3.7395E-30
Residual	60	499238.937	8320.64895		
Total	63	3715439.29			

C. Estimated the AGB using multi linear regression model with remote sensing data

The multi linear regression model applied to estimate of carbon sequestration in the PhuPhaWua Forest Park, Kalasin province. The results of spatial mapping of AGB shown in Fig 5 and the results of estimated the AGB was 1055540.80 tCO_2e.

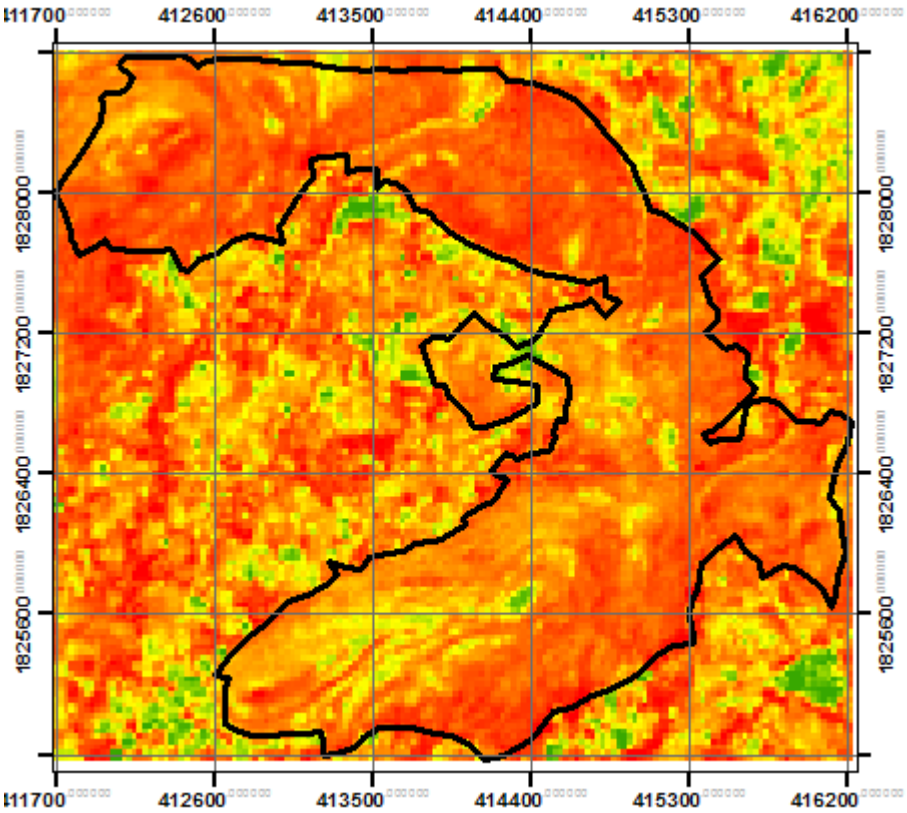

Fig 5. Estimated AGB values mapping using multi linear regression model

IV. Conclusion

The estimated of forest AGB in Phu Pha Wua Forest Park Kalasin Province, Thailand. The data collection forms the measurement the value of AGB of permanent sampling plots is a total of 62 plots. The results of field surveyed found that the total number of 4682 trees could be divide into tree and sapling tree. The calculated the forest AGB used the allometric equation was 79.6 Ton per hectare. The multi linear regression was built using these field measurements and satellite image data including NDVI, SAVI, and FVC of Sentinel-2 imagery. The results demonstrated that multi linear regression model are the optimized for estimated the AGB with the coefficients of determine. The relationship of the satellite variable of multi linear regression model show that the NDVI index was not significant for estimated the AGB values. The result of the multi linear regression show that the SAVI index was positively correlated with AGB in study area.

ACKNOWLEDGMENT

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