VALORIZATION OF HAZELNUT BIOMASS FRAMEWORK IN TURKEY: SUPPORT AND MODEL GUIDELINES FROM THE ITALIAN EXPERIENCE IN THE FIELD OF RENEWABLE ENERGY

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ABSTRACT

In this study, we illustrate the results which were obtained using a comparative protocol concerning hazelnut production framework with special references to Turkey and Italy. Investigation includes supply, exports and several internal organization patterns. Emphasis was laid on proposing agro-forest biomass derived by hazelnut cultivations for renewable energy production via small-scale applications, in order to enhance farmers' income within Turkish individual agro-districts. Due to importance of Turkey in world hazelnut trade, it is interesting to project some enhancements which have been already carried out in Italy. A consolidated protocol using DEA analyses gave evidence to the possibility of stabilizing both domestic and world prices along with differentiating hazelnut farmer's income.

Keywords: Hazelnut, Optimization, Renewable energy, Biomass, System modeling, DEA analyses.

Contribution/ Originality

This is the first known study that proposes the projection of an existing and tested experiment (that of Viterbo province in Italy) on an imposing agro-forest biomass framework (That of Turkey, the most important actor in world hazelnut production). This study is also the first to perform a consolidated protocol using DEA analyses in order to give evidence to the possibility of exploiting renewable energy and environment valorization in order to differentiate hazelnut farmer's income in Turkey.

1. INTRODUCTION

In some recent studies (Monarca *et al.*, 2009; Cecchini *et al.*, 2011; Monarca *et al.*, 2011; Monarca *et al.*, 2012), the concept of agro-energetic eco-district in some areas in Italy has been mentioned and widely discussed. Used agro-forest biomass has been claimed to have potential benefits for environment, such as reduction of CO_2 emissions, and also for farmers, because they could sell the electric power and receive green certificates. Starting from innovative plants for electric power production using agro-forest biomass, from agricultural discards as hazelnuts'

shells and pruning of hazelnuts trees, as presented by Monarca *et al.* (2009); Monarca *et al.* (2011); Monarca *et al.* (2012) and Cecchini *et al.* (2011), the objective of this study is to give a scientifically founded support to actual hazelnut policies in the favor of hazelnut farmers through increasing their real income.

2. METHODS

In the last decade Turkey has implemented new reforms concerning hazelnut production as it presents 70% of world production (Fig. 1) and 21% of total agricultural exports. It represents beyond all an important source of income for a large number of family farms (Ekinci *et al.*, 2014).

Figure-1. Hazelnut world production
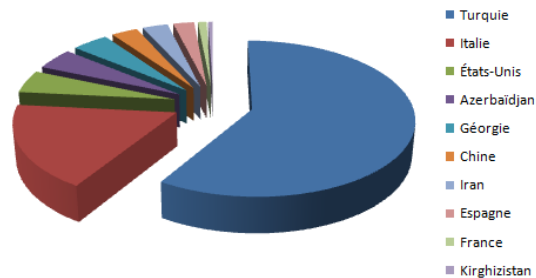
Source: FAO Document Repository, inventory of hazelnut research.

Italy is the second hazelnut producer after Turkey (Cevik *et al.*, 2009; Demiryurek, 2010; Locatelli *et al.*, 2011). Its market rules follow the policies of the European Union (EU) which affect hazelnut farmers' income and yield. These policies aimed to enhance farms' income and to analyze farms' profitability in joining the different measures. Mainly, valorization of residual biomass, obtained from hazelnut trees pruning via suitable renewable energy conversion technologies has been experimented and evaluated in the province of Viterbo. An approach to this policy is presented as a guide to the development of the similar framework in Turkey.The applied protocol is suitable for this problem as long as many similarities have been recorded between the two countries in terms of techniques, environments and human patterns.

2.1. State of the Art in Turkey

Hazelnut was native to the black sea coast long before our era, not as a cultivated product but growing in the wild on trees or shrubs on the steep slopes of the mountains that are parallel to the coast for hundreds of kilometers from east to west (Yavuz and Birinci, 1996). This production is actually spread across 33 provinces in Turkey, mostly in the Black Sea region (Fig. 2). Hazelnut is not only one of the most important export crops of Turkey, but also the main economical activity of nearly 400,000 households under the form of family farming in the Black Sea Region. These aspects of hazelnut production, which fall within the framework of multi-functionality, are seen as being the key factors in maintaining social, economic and environmental

sustainability in the rural parts of the region as well as urban areas due to the employment and trade benefits created by hazelnut processing industry. The hazelnut economy directly and indirectly supports 4 million people.

Hazelnut production is the single income source of 61% of the families in the Black Sea Region. Monoculture is a dominant character in hazelnut and tea production activities. The share of hazelnut production value in total provincial crop production value is 60,3% in Giresun, 57,8% in Ordu, 32,1% in Trabzon, 24,3% in Bolu, 17,6% in Sakarya, 9,2% in Zonguldak, 7,3% in Artvin, and 6,2% in Samsun. The base of the problem is monoculture. Small scale farmers have no other alternative except for hazelnut farming and they had to increase their production area in order to increase their family income. About 395 thousand farm families engage in hazelnut production in about 540 thousand ha. And is the only source of livelihood for 61% of hazelnut producer families. The national turkish hazelnut production is followed by Italy, the USA, Iran, and China.

**Figure-2**. Hazelnut cultivation in Turkey
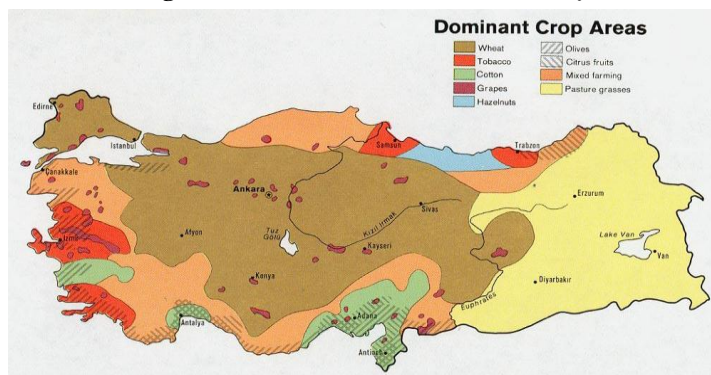
Source: FAO Document Repository, inventory of hazelnut research

About 60 percent of the crop is produced in the Eastern Black Sea Region, 15 percent is produced in the Central Region and the remaining 25 percent is produced in the Western Black Sea Region. In Turkey, the regions where hazelnut is grown can be divided into two sub-regions: a) Standard Region (eastern part of the Black Sea Region): Ordu, (the most important production area in Turkey, with a 30% share in total) Giresun, Rize, Trabzon and Artvin provinces. b) Standard Region (middle and western part of the Black Sea Region): Samsun, Sinop, Kastamonu, Bolu, Düzce, Sakarya, Zonguldak and Kocaeli provinces.

As stated by Yavuz and Birinci (1996), hazelnut production (Fig. 3) and manufacturing system in Turkey has been subjected to various policies as planting zones restrictions, price support, alternative crop payments and direct income support. In fact, in 1989 some restrictions on planting zones have been imposed in order to face stocks rise. These restrictions were followed by a program to pay producers to convert hazelnut-planted areas having young trees to alternative crops. In this context, since 2003, some farmers have been supported for Kiwi fruit as an alternative crop mostly in Black Sea region.

Figure-3. Hazelnut production evolution in Turkey
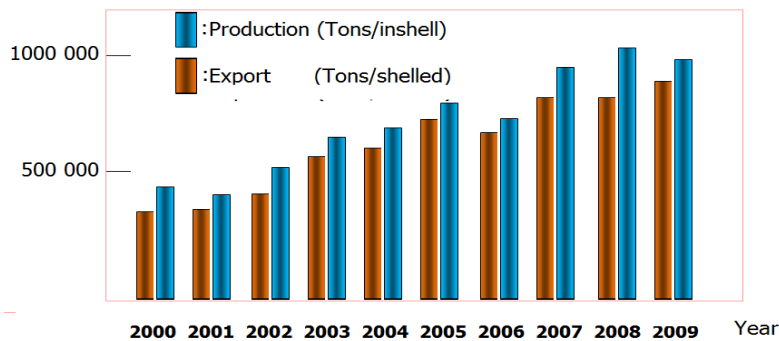
Source: FAO Document Repository, inventory of hazelnut research

2.2. State of the Art in Italy

As mentioned earlier (Delprete and Sesana, 2014), Italy is the second largest hazelnut producer in the world ahead of the United States, but behind Turkey whose huge supply dominates the world market. Italian hazelnut producers have increasingly improved their production techniques (irrigation, fertilization, pesticide use, and mechanization) enhancing yield and maintaining Italy's competitiveness in the world market. Hazelnut production is cyclical, bearing heavily in alternate years. Quality is forecast to be exceptional. Despite recent implementation of specialized farms which are sufficiently large to allow for the use of modern efficient production technologies and high quality products, hazelnut production in Italy suffer from structural weakness like reduced farms size, reluctance to replace cut trees and lack of homogeneity as regards. The hazelnut industry is concentrated in four regions: Campania comprising approximately 50 percent and the remaining production being in Piemonte, Latium and Sicily (Fig. 4). Hazelnut production in Piemonte represents 10 percent of the total Italian production of about 10 000 t. The other producing regions are Campania (50 percent) in Avellino province, Latium (28 percent) where Viterbo Province has 90% of the hazelnut cultivations, and Sicily (12 percent). Nevertheless, Italy imported 60,741 MT of hazelnuts in 2012, mainly from Turkey (46,770 MT), Georgia (7,592 MT), and Azerbaijan (3,887 MT). In the same year 2012, Italy exported 34,963 MT of hazelnuts, mostly to Germany (14,789 MT), France (6,922), and Switzerland (3,251 MT).

Hence, the future of hazelnut production in Italy depends on choices of environmental and geographical factors as well as propagation, pruning and irrigation programs mainly in central and southern Italy. Hazelnuts in Italy are sold both in-shell and shelled shape. In-shell hazelnuts are generally sold as a snack for fresh consumption while shelled ones are usually employed as a raw material for confectionary and bakery food companies. Furthermore, low quality shelled hazelnuts are often used by cosmetic companies. Approximately 90% of the Italian harvest goes to processing companies, whereas fresh consumption represents the remaining 10 percent.

Figure-4. Hazelnut cultivation in Italy

Source (original)

2.3. Highlights from a Research in an Italian District in the Province of Viterbo

In Viterbo province hazelnut cultivation represents an agricultural and economic reality of great importance for the farmers of this province. "Blooming of this cultivation began in '50's and since then, a remarkable increment has been recorded, growing from 2.000 Ha to 20.000 Ha at present (Fig. 5). This expansion involved 17 communes of the province and, for many of these, this cultivation represents the only agricultural activity (Contini *et al.*, 2012; Moscetti *et al.*, 2013; Delprete and Sesana, 2014). In Italy the province of Viterbo is the first pole of hazelnut production (30.000 - 40.000 ton/year). The rapid development of the cultivation can be attributed to the characteristics of climate and soil of Monti Cimini area: grounds with reaction near the neutrality, tendentially sandy, sub Mediterranean climate with just combination of not too much rigid winters and annual medium rainfall higher than 1.000 millimetres.

Figure-5. Hazelnut's farm distribution in the Viterbo Province

Source: (Monarca *et al.*, 2012)

Hazelnut pruning, during January and March, is a cultural operation demanding care and long times (approximately 4 d/ha), because usually the maintenance pruning is carried out every year, however currently the pruning is still executed by hand, using chain saw only for cutting larger branches (Fig. 6). In some cases, especially on old or sick hazel groves, the development of

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a new productive structure is stimulated by cutting the main branches ("regeneration pruning"). Hazelnut pruning stays on the soil only for a short time since it will be eliminated by the shredders. At present in the province of Viterbo in most cases the pruning is burned on the soil but rarely it is utilized as a source of energy in burning stoves or in boilers purposely manufactured by local companies. In summer besides the pruning, suckers are removed before the harvest. Recent works have investigated the possibility of enhancing hazelnut processing waste and, at the same time, of reducing environmental impacts associated with the pruning residues management in Italy. The pruning residues used to be consumed as combustible for the family fireplace or directly burned on the field. Biomass as a yield of pruning crops operation represents an interesting and attractive resource to be exploited in different ways, e.g. fuel for energy production, or transformed into compost and later used as an organic fertilizer and can be seen as a suitable solution to produce energy by means of thermo-chemical processes, namely combustion, gasification and pyrolysis.

Figure-6. Hazelnut energetic potential by hazelnuts pruning in Viterbo's area

Source: (Monarca *et al.*, 2012)

In the region of Viterbo in Italy, the time of pruning biomass is strongly linked to the cultivation yield: from January to March, though also in a limited time somehow in April, May, June or July, where a significant increase is shown two or three years later after first pruning. So the quantity of biomass cannot be distributed in a yearly yield, as constant as pine or beech, or others species of tree. For example, the pruning of hazelnut plants of 25 farms which are situated in the south-east area of the province of Viterbo, was approximately 30,000-40,000 tons (Contini *et al.*, 2012).

The University of Tuscia in Viterbo has carried out a study on the amount of pruning resulting from the hazel of Viterbo . The results indicate an average production per plant that is around 6.37 kg and an average production of about 1,950 kg per hectare for pruning and

maintenance for summer pruning waste production is 1.67 kg / plant equal to 446 kg / ha . In the total area covered with hazelnut trees, of which a large part in adulthood, the study estimated an annual production of biomass, of about 39,000 tons by the only maintenance pruning and about 8,900 tons resulting from pruning , as a total biomass of about 48,000 tons per year. Actually, in most cases those residues are burned on the field, but in few occasions arevused for combustion in the walk, stoves and boilers (Fig. 7). However, these data show that it is possible to think of a more complete recovery for energy pruning residues .

**Figure-7**. Production Nutshell and pruning (biomass)/solid fuel boiler applied to a dryer

Source: (Cecchini *et al.*, 2011)

Knowing the net calorific value of the hazelnut wood and the number of hectares cultivated for each municipality, a map of thermal potential energy has been realized. The study we mentioned was carried out on a sample of more than 200 hectares area, of the most productive areas in the Province of Viterbo, through 25 farms, form the most important of the considered areas. Other variables are: the pedo-climatic environment and plant age, the pruning cut method - i.e. manual or mechanical operations - which strongly affects the amount of residual biomass and the health conditions of the plant itself. In case of intensive farming of hazelnut (number of plants per hectare), the pruned biomass reaches an average value of 1,848 kg/ha. There is also a difference in yield pruning, between manual and mechanical methods: manual pruning leads to produce a higher quantity of biomass.

Studies (Monarca *et al.*, 2012) on the quantity of pruning per hectare and the analysis the humidity of the biomass harvested showed that the average value of biomass weighted was just under 0,9 t/h. The age of the hazelnut tree has to be considered because the highest quantities of hazelnut pruning were obtained from 21 to 30 years old-plants; it seems that the amount of biomass does not show an increasing trend after this age. In laboratory conditions, biomass characterization has obtained the following results, considering moisture and ash, determined on weight fraction on dry basis (wt. % on dry basis). Carbon (C), hydrogen (H), oxygen (O) and nitrogen (N) contents were determined using fraction on mass (% on mass) as it can be seen in Fig. 8.

Figure-8. Hazelnut biomass composition
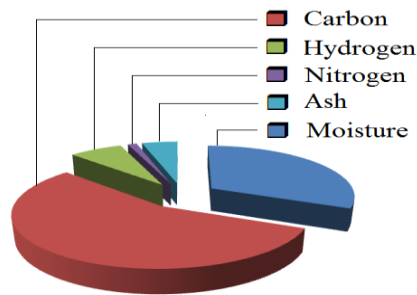
Source: (Monarca *et al.*, 2012)

This study stated that hazelnut trees pruning have similar values in terms of ash content, C, N, H, C/N and lower calorific value that hazelnut shells while moisture content is higher in hazelnut residues. The contents of C, H, N show that these biomass fuels have a higher share of carbon content compared to hydrogen and nitrogen, which increases their energy value. As conclusion, the residual biomass, obtained from hazelnut trees pruning, can be successfully considered as a real economical opportunity and as an attractive chance for a community of farms, It is also the matter of choosing the most suitable conversion technology: since this type of woody biomass is similar to hazelnut shells, combustion or gasification seems to be the most appropriate solution, as in some Italian municipalities where farm by farm, the pruning is harvested and used to warm public buildings or schools after been transformed in pellet. The largest quantities harvested can supply part of the growing energy demand and can be efficiently used in domestic or district heating.

In some previous studies, it has been demonstrated that biomasses derived from hazelnut cultivation and processing (Fig. 9) , can be used as a source for energy production due to its chemical and physical peculiarities, in thermo chemical processes such as combustion, pyrolysis and gasification. Furthermore, the considerable variability of bio-fuels that can be produced allows the experimentation of new technologies which, with a higher performance, are able to produce not only heat but also electric power, while the main disadvantage of such energetic systems consists in its difficult application in a large scale production.

Figure-9. Hazelnut world production
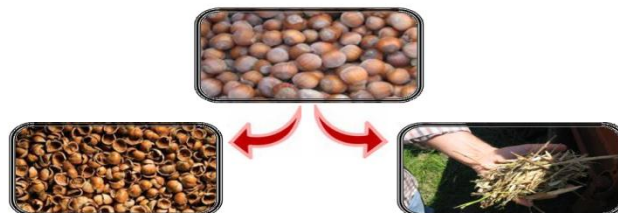
Source: (Monarca *et al.*, 2012)

It was also highlighted that the possible use of biomasses in small energetic districts such as the area of Viterbo through the exploitation of wood and cellulose biomasses lies on the feasibility of a biomass supplied system, taking care of stocks availability and amount, use of the gasification process based on flowing bed technology, chemical characteristic of syngas and energy power production. In Viterbo, considering the winter trimming of *Corylusavellana* on a surface of 48,7 ha, and during the 2004/2007 period, produced, the resulting annual amount of biomass ranges from 1.5 to 3.1 t*ha^{-1} with a mean value of 2.4 t*ha^{-1}. Considering a kg of biomass/producible *kWe* ratio equal to 1.3, given by the gasification process based on fluidize bed technology, it is possible to estimate a potential production of electric power of 90 MW.

Planned small biomass gasification power plants in Viterboprovide a competitive way to convert diverse, highly distributed and low-value lignocellulosic hazelnut waste biomass to syngas for combined heat and power generation with electrical and cogeneration efficiencies about 20% and 80% and a global capital cost of about 500-1000 €/kWe.

3. RESULTS

3.1. Proposals and Perspectives in a Comparative Framework

The main actual problem is that realincome of hazelnut farmers in Turkey has decreased year by year despite productionlevel increase. Compensation payment, removal of hazelnutplantations on flat lands and price policy seem to be not enough beneficial for thehazelnut farmers. In Italy, and in the framework of local hazelnut farmers' income valorization, real opportunities for the development of small scale biomass gasification systems have been demonstrated. Recent growth of the local power generation by means of renewable energies technologies in concordance with biomass feedstock suitable for gasification focuses on low cost and low environmental impact hazelnut residues. The example of the Mid-Term Review of the Common Agricultural Policy on the hazelnut farms in the Viterbo province is a good representative new support scheme.

Since the potential offered by hazelnut biomass to reduce greenhouse gas production is now recognized, Italian farmers carried out gasification works which were concentrated on woody biomass. Hazelnut shells and pruning wastes were hence identified as large energy production potential source and pilot scale downdraft gasifier has been already investigated. It was recorded that hazelnut shells produce good quality gas with minimum polluting by-products and, as lignocellulosic wastes, are potential sources of pentose and hexose sugars (xylose, glucose) which can be used as a raw material for production of food enzymesusing i. e. dilute-acid hydrolysis.

Hazelnut residues in Turkey can be divided into three groups: annual crop, perennial (after pruning) and agro-industrial residues. These residues are actually treated in an uncontrolled manner in Turkey, they are either burnt in openair fires or disposed of to decay, giving rise to many environmental issues. Similarly to the Italian case, pruning hazelnut trees is a traditional act which has been carried out through generations in order to optimize productivity, facilitate harvesting and developing solid tree structures. In fact in most Turkish areas, hazelnuts are produced on new wood and hence repetitive pruning promotes the growth of new shoots. Pruning

reduces also limb breakage from ice and snow. Traditional pruning consists of annual removing of one-half of the fruiting area from one-fifth of the trees in order to suppress the alternate-year bearing tendency of mature hazelnut trees.

In another context, Turkey is an energy importing country. More than about 63% ofenergy consumption in the country is imported. It is of great interest to supply energy demand by using domestic renewable resources, taking into account Turkey's geographic location which has several advantages for extensive use of most of the renewable energy like hydro, biomass, wind, geothermal and solarsources. Nevertheless, biomass energy use faces some problems like small farming size, environmental risks, lack of commercial harvesting machinery and eventual low opportunity cost.

For Turkey, it may be suggested hence that small-scale gasifier plants and pruning wastes management can make an important contribution to the economy of rural areas where the residues of nuts are abundant (Black Sea region) thus warranting further investment/encouragement by authorities to exploit this valuable resource.As a tangible proposal, we can help the experimentation of innovative experimental gasifier plants for electric power production using agro-forest biomass derived by hazelnut cultivations. The experimental gasifier(Fig. 10) is a fixed cocurrent bed, fed with hazelnut shells or pruning residues . The developed prototype is a small sized plant. The electrical capacity is 30kW and the thermal power reaches 60kW. The internal structure is made of stainless steel 304.

Figure-10. Hazelnut world production

Source: (Monarca *et al.*, 2012)

The analysis of the synthesis gas (syngas) allows determination of the molecular species present in the gaseous mixture obtained as the result of hazelnut shells gasification inside the experimental gasifier presented in this paper. The carbon dioxide resulting from partial combustion process takes place simultaneously with biomass gasification. The prototype worked properly producing good quality syngas. However, it should be noted that it could be improved, providing a better automation and electronic system. We have tried to give evidence to the mapping of the potential of agricultural waste exploitation and show a technology application in order to assess a technological solution available in Turkey. The starting idea is that energetically

independent agro-forest farms can use agro-forest biomass, like agricultural discards as hazelnuts' shells and pruning of hazelnuts cultivation can be renewable sources to generate electric power.

In conclusion we can establish that some 600.000 tons of hazelnut pruning wastes from all Turkish orchards could be transformed in 88.5 MW of electrical power.

During the last decade, Turkish government has gradually reduced its interventions and support prices . Nevertheless, and since hazelnut sector is not monopolistic, an appropriate action is to create new off-farm income sources (rural tourism, rural industrialization, forest/animal products etc.) as long as hazelnut production is the only source of livelihood for 61% of hazelnut producer families.

As hazelnut is a valuable and sensitive horticultural product at international levels, the following protocol focuses on Turkish farmers' income enhancement via shell and pruning waste valorization according to the Italian example along with certain growing conditions/cultural management techniques affecting both nutritional value of hazelnut varieties and economic income.

3.2. Optimization Protocol

Perspectives evaluation is carried out using the Data envelopment analysis (DEA) method. This method has been implemented by Farell (1957) followed by Banker *et al.* (1984) and Charnes *et al.* (1978), as a protocol to evaluate efficiency. In this protocol, a set of decision making units (DMU) share common inputs to produce an output (or a set of outputs). Thanks to an optimization protocol, an efficiency frontier, which includes all the efficient DMUs, while the remaining ones are considered as inefficient.

The initial dataset is composed of N_o observations (DMU) (N_o=7) with six input variables $x_i\big|_{i=1..6}$

andtwo output variables y_1 and y_2.

Input dimensionless variables are chosen as:

- ✓ x_1 : Total expected hazelnut production in 2025

- ✓ x_2 : Expected hazelnut market selling price in 2025

- ✓ x_3 : Fraction of expenses to Gross Value of Crop in 2025

- ✓ x_4 : Fraction of renewable-energy and gasification yield to Gross Value of Crop in 2025

- ✓ x_5 : Unitary cost of pruning revalorization per production unit in 2025

- ✓ x_6 : Unitary cost of additional maintenance harvest and transport in 2025

Output dimensionless variables are:

- ✓ y_1: Expected hazelnut farmer's income per capita*.

- ✓ y_2: Expected global hazelnut-related income*.

  (*compared to the situation of non-use of the actually proposed scheme)

Some realistic assumptions are taken into account, i. e. in large economies, renewable energy is expected to contribute at least 35% of all electric power by 2025, and overall investment costs are supposed to follow EWI (2010) estimations (Table 1).

Table-1. EWI estimation (partial data)

(EWI, 2010)	Mean investment cost (M. U. per kW (in 2015))	Lifetime (Years)
Coal	1275	40
Gas	550	30
Oil	450	25
Biomass	255	20

Source: (EWI, 2010)

For standardizing purposes, each variable t which varies inside the range $[t_{min}, t_{max}]$, is normalized using Eq. 1:

$$\hat{t} = \left[\frac{t - t_{min}}{t_{max} - t_{min}} \right] (1)$$

For a general *N*-input *M*-output problem, the efficient frontier gathers the optimal DMUs which verify the following conditions:

For each *k*-ranked DMU among the N_0 ones, we set: $S^k = \dfrac{\sum\limits_{m=1}^{M} u_m y_m^k}{\sum\limits_{n=1}^{N} v_n x_n^k}$ (2)

where x_n^k et y_m^k are the unit's output and input variables respectively, $u_m\big|_{m=1..M}$ and $v_n\big|_{n=1..N}$ are weight coefficients

It is evident that the values of $u_m\big|_{m=1..M}$ and $v_n\big|_{n=1..N}$ depend on the totality of the observations. The variable S^k represents the DEA score S affected to the kth DMU, score which corresponds, in the actual case, to the value which verifies:

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$$S^k = Min\left(\frac{\sum_{m=1}^{2} u_m y_m^k}{\sum_{n=1}^{3} v_n x_n^k}\right)\Bigg|_{\substack{\left|\frac{\sum_{m=1}^{2} u_m y_m^j}{\sum_{n=1}^{3} v_n x_n^j}\geq1\right|_{j=1..20} \\ u_m \geq 0; v_n \geq 0}} \qquad (4)$$

4. DISCUSSION

Figure 11 represents the output observations as DMUs representation along with the efficiency frontier. Concordantly with earlier records, one could report results for the standard DEA efficiency scores of each of the 7 considered observations. It is possible to observe i.e. that two observations (DMU 5 and 2) would be labeled as the most efficient ones with the standard DEA approach: These observations are in the efficiency frontier (Fig. 4).

DMU 2 and 5 correspond to scenarios of maximum total relative savings with implementation of renewable-energy and gasification units in Turley at 2025 horizons.

These scenarios do not differ significantly concerning total production in 2025 and the last DMU could have been equally efficient if it was not corresponding to a low investment rate in hazelnut residues revalorization.

Figure-11. Decision Making Units (DMUs) along with the Efficiency Frontier [in ($\tilde{y}_1$, $\tilde{y}_2$, S)-coordinates]
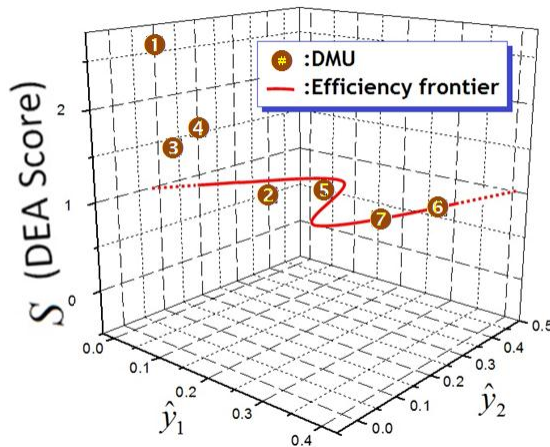
Source: (Original)

The two scenarios take into account different transmission infrastructures which are projected in Turkey for 2025, in concordance with the previsions of Aytav and Kocar (2013), Demirbas (2008), Kaygusuz and Sarı (2003), Bilgen *et al*. (2008) and Kaygusuz and Türker (2002).

5. CONCLUSIONS AND POLICY IMPLICATIONS

Hazelnuts wastes in Turkey have the potential to produce twice the amount of oil per acre and renewable energy as other many other agricultural sources without annual planting costs. In this work we have tried to discuss the actual situation in matter of hazelnut farmers' income in Turkey in the light of some precedent investigation in Italy. We have evaluated efficiency once by solving a standard DEA problem with normalized DMUs. We have mainly demonstrated the positive aspect of valorisation of biomass hazelnut shells and pruning residues within the related policy implications framework *et al.*(Bilgen *et al.*, 2008) and Kaygusuz and Türker (2002).

. Secondly, we tried to evaluate efficiency at the vicinity of the efficiency frontier using new metrical tool. The proposed protocol could be a supply to recent corrections (Räty, 2002; Amirteimoori and Kordrostami, 2005) conducted on the DEA classical model in the context of evaluating the eventual environmental factors biasing effects.

As local interests and national priorities do not seem to be in good agreements, the actual model, which supposed the existence of a common energy policy, is being revised in order to take into account this issue and evaluate separately, short-term and long-term features.

REFERENCES

Amirteimoori, A.R. and S. Kordrostami, 2005. Efficient surfaces and an efficiency index in DEA: A constant returns to scale. Applied Mathematics and Computation, 163: 683-691.

Aytav, E. and G. Kocar, 2013. Biodiesel from the perspective of Turkey and the world: Past, present and future. Renewable and Sustainable Energy Reviews, 25: 335-350.

Banker, R.D., A. Charnes and W.W. Cooper, 1984. Some methods for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30(9): 1078-1092.

Bilgen, S., S. Keles, A. Kaygusuz, A. Sarı and K. Kaygusuz, 2008. Global warming and renewable energy sources for sustainable development: A case study in Turkey. Renewable and Sustainable Energy Reviews, 12(2): 372-396.

Cecchini, M., M. Contini, R. Massantini, D. Monarca and R. Moscetti, 2011. Effects of controlled atmospheres and low temperature on storability of chestnuts manually and mechanically harvested. Postharvest Biology and Technology, 61(2–3): 131-136.

Cevik, U., N. Celik, A. Celik, N. Damla and K. Coskuncelebi, 2009. Radioactivity and heavy metal levels in hazelnut growing in the Eastern Black Sea Region of Turkey. Food and Chemical Toxicology, 47(9): 2351-2355.

Charnes, A., W.W. Cooper and E. Rhodes, 1978. Measuring the efficiency of decision making units. European Journal of Operational Research, 2(6): 429-444.

Contini, M., S. Baccelloni, M.T. Frangipane, N. Merendino and R. Massantini, 2012. Increasing espresso coffee brew antioxidant capacity using phenolic extract recovered from hazelnut skin waste. Journal of Functional Foods, 4(1): 137-146.

Delprete, C. and R. Sesana, 2014. Corrigendum to mechanical characterization of kernel and shell of hazelnuts: Proposal of an experimental procedure. Journal of Food Engineering, 124(2014): 28-34.

Delprete, C. and R. Sesana, 2014. Mechanical characterization of kernel and shell of hazelnuts: Proposal of an experimental procedure. Journal of Food Engineering, 128: 174-177.

Demirbas, A., 2008. Importance of biomass energy sources for Turkey. Energy Policy, 36(2): 834-842.

Demiryurek, K., 2010. Analysis of information systems and communication networks for organic and conventional hazelnut producers in the Samsun province of Turkey. Agricultural Systems, 103(7): 444 - 452.

Ekinci, R., M. Otag and C. Kadakal, 2014. Patulin & ergosterol: New quality parameters together with aflatoxins in hazelnuts. Food Chemistry, 150: 17-21.

EWI, 2010. European RES-E policy analysis. A model-based analysis of RES-E deployment and its impact on the conventional power market. Final Report April 2010, Cologne.

Farell, M., 1957. The measurement of productive efficiency. Journal of the Royal Statistical Society, Series A (General), 120(1957): 253-281.

Kaygusuz, K. and A. Sarı, 2003. Renewable energy potential and utilization in Turkey. Energy Conversion and Management, 44(3): 459-478.

Kaygusuz, K. and M.F. Türker, 2002. Biomass energy potential in Turkey. Renewable Energy, 26(4): 661-678.

Locatelli, M., J.D. Coïsson, F. Travaglia, E. Cereti, C. Garino, M. D'Andrea, A. Martelli and M. Arlorio, 2011. Food Chemistry, 129(4): 1865-1873.

Monarca, D., M. Carlini, M. Cecchini and A. Colantoni, 2009. Gasification of agroforestry biomasses by means of a multi-reactor gasifier for electric power production: Experimental tests and syngas analysis. Annual Review of Agricultural Engineering, 7: 57-64.

Monarca, D., M. Cecchini, A. Colantoni and A. Marucci, 2011. Proceedings of the Computational Science and its Applications (ICCSA '11), of Lecture Notes in Computer Science, Springer, Santander, Spain, 4: 307-315.

Monarca, D., A. Colantoni, M. Cecchini, L. Longo, L. Vecchione, M. Carlini and A. Manzo, 2012. Energy characterization and gasification of biomass derived by hazelnut cultivation: Analysis of produced syngas by gas chromatography. Mathematical Problems in Engineering, 2012: 1-9.

Moscetti, R., R.P. Haff, B. Aernouts, W. Saeys, D. Monarca, M. Cecchini and R. Massantini, 2013. Feasibility of Vis/NIR spectroscopy for detection of flaws in hazelnut kernels. Journal of Food Engineering, 118(2013): 1-7.

Räty, T., 2002. Efficient facet based efficiency index: A variable returns to scale specification. Journal of Productivity Analysis, 17: 65-82.

Yavuz, F. and A. Birinci, 1996. Findikve diger sert kabuklu meyveler sempozyumu, Ondokuz Mayis Universitesi Ziraat Fakultesi, Samsun, S: 1-11.