

AN INVESTIGATION OF FIVE GENERATION AND REGENERATION INDUSTRIES USING DEA

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Abstract: *The data envelopment analysis (DEA) has employed to figure out the efficiency of various engineering projects in the Environment Impact Assessment (EIA) plan and Post-EIA. The procedure allocated to comprise the input and output variables within industries by the present study. The study was used both weighing systems of the Friedman test and the CRiteria Importance Through Intercriteria Correlation (CRITIC) model in the estimation of DEA. The objective of the research sought to find the efficiency of industries for the time interval before the establishment of industries and in the screening step of identification of projects. The findings manifested a classification of industries based on the DEA model and in both weighing systems. Using different weighing systems creates different categories via DEA. Overall, the DEA model is an essential decision-making model in the screening step of EIA.*

Keywords: *Industries, Recycling, EIA, Screening, Projects, Assessment*

1. Introduction

The first use of plastic films in agriculture applications dates back to 1948. In recent years, with the increasing population and the declining trend of water resources, many countries have made extensive efforts to apply drip irrigation systems to avoid the risks associated with water shortages in agricultural production, modern agriculture, and water use (Jha 2016; Usman et al., 2016). Plastics have used in various applications in agrarian usages. Perhaps that is why polymer films, as one of the plastic applications in this field, are interpreted as a revolution that can be extended by expanding their use in all regions of the world to solve many problems related to drought and depletion of water resources. The main applications of polymer plastic films in agriculture are divided into the following. (1) Mulch films (2) Greenhouse and tunnel coverings (3) Silage packaging films (4) Solarizing films (5) Geo-membranes, etc. From all these applications, greenhouse and tunnel coatings are the largest in terms of quantity consumption. The thickness of films used in this application is usually between 80 to 220 micrometers. They have used in one to

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seven layers depending on the existing technologies in the countries. More than 80% of this market has accommodated by films made of Light Density Poly-Ethylene (LDPE), Ethylene Vinyl Acetate, and Ethylene Butyl Acrylate (Difallah et al., 2018). Today, the lifespan of these coatings varies between 6 months to ten years depending on the geographical location of the region, the polymers used in the greenhouse, and the formulation of various film stabilizers. The European standard DIN EN 13206 has provided guidelines in thermoplastic coatings for use in agriculture and horticulture for measuring the lifespan, dimensions, mechanical properties, light, and the degree of impermeability of infrared waves. The greenhouse and tunnel coating market is a particular market that requires significant investments in massive extrusion lines to produce vast films. Most of these films are produced by the blowing film process. Problems in stabilizing these large bubbles are one reason why LDPE is used in the production of these films, instead of LLDPE, due to the lower strength of the melt. In such cases, when co-extrusion lines are used, the technical complexity and quantity of investment increase significantly. The polymer films and coatings are affected by light, temperature, and chemical degradation during use. Therefore, they need requirements that are strongly dependent on environmental parameters for a long lifespan. Environmental parameters encompass the type of structure, its design, height, air conditioning, geographical parameters (sunlight and its intensity, temperature, rainfall, altitude, etc.), and chemicals used in the products (Jumanne, 2016). It is impossible to achieve all these properties without the use of special additives and the generation of multilayer structures. That is why in recent years the tendency of developed countries has been more towards producing films of five layers and higher. With the development of metallocene catalyst technology, and plasma reactors, new generations of plastics materials, known as enhanced polymers and polymers made up of chemical vapor deposition, were introduced. This generation of plastic products has extraordinary properties compared to ordinary plastics due to their modern manufacturing technologies. These properties include high melt strength, impact resistance, excellent perforation resistance, high transparency, and unique thermal properties. These particular properties make modern plastic products ideal materials for such applications that require high performance (Kado et al., 2004; Peeters et al., 2014).

Another application of plastic materials in the framework of Polyvinyl Chloride (PVC) films are also discussed in this study is their use in the production of drippers in the sprinkler irrigation system, for which many industries have developed in Iran. Drip irrigation is the slow dispersion of water on the surface or under the soil in the form of separate, continuous, narrow streams or delicate sprays through droppers located along the water transfer line. The recent studies of the International Committee on Irrigation and Drainage for the issues of drip irrigation show that one of the main difficulties in drip systems is the clogging of drippers in all countries of the world. The issue of obstruction is either due to the lack of use of water of good quality or improper selection of the treatment system, which results in uneven distribution of water along the sub-pipes. Thus, it reduces irrigation efficiency. The risk of clogging the drippers also increases the cost of maintaining and operating the system, including controlling the drippers and replacing or repairing them (Taylor and Zilberman, 2017; Gutiérrez et al., 2013; Wang et al., 2016; Raju et al., 2012).

The agricultural waste has proliferated and vast quantities of agrarian straw and animal waste produced during recent years. So, investigations suggested setting up an effective recycling program via supporting and encouraging governmental policies

(Gutiérrez et al., 2013; Wang et al., 2016). The annual reports indicate that India has generated around 400 million tons of agrarian waste (Raju et al., 2012). Agrarian waste has been used in many applications, even utilized to remove dyes from wastewater by Bharathi and Ramesh (2013). The use of agricultural waste has applauded to generate bioethanol in various studies and cardboard in the current study (Hossain et al., 2008). Therefore, the industrial projects of discussed options posed to assess in EIA.

One of the most essential instruments on which to consider environmental considerations in the planning system is the EIA. Today, in many countries, the EIA is one of the most critical strategic instruments of environmental management. To integrate environmental considerations in the planning and developing process at the highest levels, EIA is considered as the most essential decision-making instrument. The environmental assessment in the service of sustainable development leads to progress towards sustainability and, consequently, improved the indicators of sustainable development including all economic, social, institutional, and environmental dimensions. Protecting the environment, in which future generations should thrive in social life, is a public duty. It is necessary to raise awareness about this plan. It is essential to act strategically, not in the tactical field.

In general, environmental assessment is defined as a method by which a correct understanding of the position, role, function, and effects of any natural or human-made phenomenon in the environment is formed. Thus, it is possible to determine the circumstances of the assessment that is related to the environment, its interaction, and the kind of processes and reactions between them. According to the International Union of Impact Assessment, EIA is a plan to reduce biophysical, social, and other impacts associated with the proposed development before the primary decision and executive action. Analyzing the effects is a coherent scientific tool used to identify, summarize, and organize information related to the environmental impacts of policies, programs, and plans. In strategic & environmental assessment, the analysis and evaluation phase is one of the most critical parts of EIA studies. In this section, the current situation and predicted effects on physical and chemical, biological, socio-economic, and cultural environments are reviewed and analyzed. In fact, in this section, all information and forecasts, (both qualitatively and quantitatively), are standardized and presented in reviews and reports. In this section, according to the description of study services, to understand the significant and essential effects, all impacts are examined and analyzed according to their intensity, importance, and nature so that decisions be made based on them. Today, there are several methods for evaluating and analyzing the effects of implementing policies and programs, each of which has its advantages and disadvantages (IEEM, 2006). Being able to implement these policies and practices may be contrary to today's conditions or nature. However, arrangements can be made for the necessary precautions and measures to be taken.

The purpose of the monitoring program is to obtain information that identifies the effects and consequences of the various policies, programs, and activities. The monitoring program should provide a complete description of the techniques used. Regarding sampling methods, the essential equipment should be presented in the monitoring program. Therefore, it is indispensable that experts of environmental assessment and other relevant staff in various fields and disciplines must be recruited in this team who can evaluate the multiple dimensions of strategic

decisions, policies, and programs with a macro perspective. The following data are related to the project screening step according to the EIA plan to underpin the efficiency score of five industries in Iran (Vallero, 2004; Hassanpour, 2020; Dubey and Dai, 2006; Bahrami et al., 2016; Mansour and Kesentini, 2008). Our studies declare that there is no similar study investigating the efficiency of Iranian industries in the screening step of the EIA plan across Iran. The motivation of the present research gets back to existing difficulties in the way of recently developed and outlined enterprises due to the sanctions approved against the Iranian government. The objective of the paper was to figure out the efficiency of industries based on recent prices for the input and output variables of industries in the market of Tehran, Iran.

2. Literature review

The efficiency assessment based on the DEA model takes into consideration the input and output variables. DEA model measures productivity performance based on financial indicators. In this model, if we add other inputs and outputs (net sales, net profit margin, net profit/equity, net profit / total assets, etc.) to the model, different results may occur. For this reason, we can achieve the desired results based on the selected data in the model. Statistics can sometimes provide us with this.

The division of output to input values releases the DEA rank. For example, the sustainability of suppliers has assessed via the Fuzzy DEA model. By the way, the variables allocated in 15 rows in inputs and outputs variables (Zhou et al., 2016). The input and output variables introduced to the DEA model based on the constant return to scale encompassed total outlays, CO₂ dissipation, the number of stations, weekly turn up, and the number of users in the investigation of two rail lines holding six and sixty stations in London, respectively (Taboada and Han 2020). Chinese industries underwent an efficiency assessment using the DEA model in seven years. It has been classified based on efficient and inefficient industries in the provinces (Xiong et al., 2017). A study addressed the DEA model as a potent instrument in economic prosperity assessment at national levels in energy and environment (Sueyoshi et al., 2017). The precision and reality of the DEA model (slacks-based measures) have investigated with other models. The comparison was reported with enough validity (Shermeh et al., 2016). The DEA model has been taken into consideration the efficiency and performance assessment of seven Indian chemical industries. The findings classified efficient industries with an efficiency border range of the lowest to highest, around 0.713 to 1, respectively (Anthony et al., 2019). A study introduced a type of DEA model in assessing the seven operational research techniques in business tax. The model succeeded in offering responses of efficient industries and was extendable to similar models in this regard (Santos et al., 2018). The efficiency assessment of wind turbines resulted in finding the inefficient cases regarding input variables of wind speed, wind power density, anemometer tower, and wind frequency and tower height and output variables of space between turbines, their directions, and the number of turbines in China (Niu et al., 2018). Bulak and Turkyilmaz, (2014) evaluated 744 Turkish suppliers at the efficiency level in a full list of input and output criteria and variables. The footprint of significant air pollutants emitted into the atmosphere by industrial sectors has assessed via the DEA model in European Union (Zurano-Cervello et al., 2018). In evaluating the agricultural enterprise, the DEA model assigned to release the efficiency score based on financial indicators. The

excellent ranking system developed in the following calculations (Fenyves et al., 2015). The performance assessment of both Turkish and Chinese companies used the DEA model to detect the ranks, and, in the estimation, the canonical correlation analysis employed as a weighing system. The classification of efficient and inefficient industries paved the way for comparing the companies between two countries (Bayyurt and Duzu, 2008). The DEA- returns to scale model has assigned to assess the efficiency score of air transport sectors in 30 provinces in a matrix of 3×3 input and output variables in 2017 in china. According to the results, the majority of sectors appeared with full efficiency or very close values to the top efficiency border (Song et al., 2020).

Andrejić and Kilibarda (2016) employed the Principal Component Analysis - DEA model for figuring out and improving the efficiency of distribution channels of products regarding 16 inputs and 17 outputs variables. The reasons for failure, efficiency fall, and circumstances of efficiency rise have discussed and offered options for expansion and improvement in the efficiency of distribution channels. The results pointed out to improvement of efficiency in four sections within the distribution channels. Blagojević et al., (2020) used the Fuzzy Analytical Hierarchical Processes – DEA model to investigate the performance of nine freight transport railways by selecting five main criteria. The border of efficiency determined in a range of around 0.242 to 1 in both systems of CCR and BCC. A study applied both models of CCR and BCC of the DEA model and correlation analysis for determining the efficiency of five automotive companies based on financial statements in Europe. Findings revealed total efficiency for the mentioned cases (Papouskova et al., 2020). DEA model based on returns to scale in both systems of CCR and BCC has examined to realize and classify thirty-five Indian small and medium-sized industries in facing lean and sustainability-oriented innovation. The score of efficiency placed the industries in a certain interval of 0.832 to 1, and most of them were efficient. A combination of both orientations helps the industries move towards sustainability (De et al., 2020). In Brazil, the logistics modes of some projects outlined in transport and cargo handling operation have taken into consideration via the DEA-CCR model consist of 12 alternatives, four inputs, and one output variable from 2008 to 2012. The results emerged with full efficiency for all years of study except for 2010. By the way, it offered some improvement options to escalate the efficiency score and impede falling in efficiency reported (Lepchak and Voese, 2020). By a combination of the Entropy-Fuzzy PIPRECIA-DEA model and the presence of six inputs and five outputs, decisions have made in the field traffic safety of nine railways in Bosnia and Herzegovina. Due to significant low efficiency and high risk in safety, two alternatives were held back in the following calculations. The sensitivity analysis has conducted to verify the findings by alteration in quantities of variables in a variety of scenarios (Blagojevic et al., 2020). The DEA-CCR model has taken into consideration for determining the efficiency of airlines due to a significant decline in efficiency score during the pandemic of Covid-19 in Asia. It used three inputs and three outputs key variables in the study. The findings proved a significant decline in the performance and efficiency of airlines. To evaluate the monthly performance of the egg generation in a poultry house, integration of DEA (Slacks-Based Measure)-CRITIC-gray model has applied. A sample of 8000 chickens selected to breathe in proper conditions of feed and maintenance to evaluate the efficiency in various months of the year (15 months) in Çukurova. In the study, three inputs and two outputs variables composed the framework of the data matrix to assess. A sensitivity analysis has done using four

models of multi-criteria decision-making to examine the validity of results. The final examination had shown a different classification in models for efficiency score (Kucukonder et al., 2019).

To figure out the efficiency score, the DEA model has been considered in a variety of researches pertaining to financial variables and indicators during a specific time interval in the studies conducted by Arab et al., (2015), Kettiramalingam et al., (2017), Raithatha and Komera (2016), Bagh et al., (2016) in the field of Indian manufacturing companies, an Indian cement industry, executive compensation relation between Indian companies and fifty Pakistani companies on the stock market respectively.

3. Methodology

3.1. Screening of projects

By the current study, the initial data were picked up from the screening step of industrial projects by evaluator teams and were investigated to estimate the efficiency of industries (according to Figure 1). To estimate the efficiency of industries via DEA model was assumed 270 working days per year. The variables were multiplied in the working days. To calculate the costs was used the daily prices in the market of Tehran, Iran.

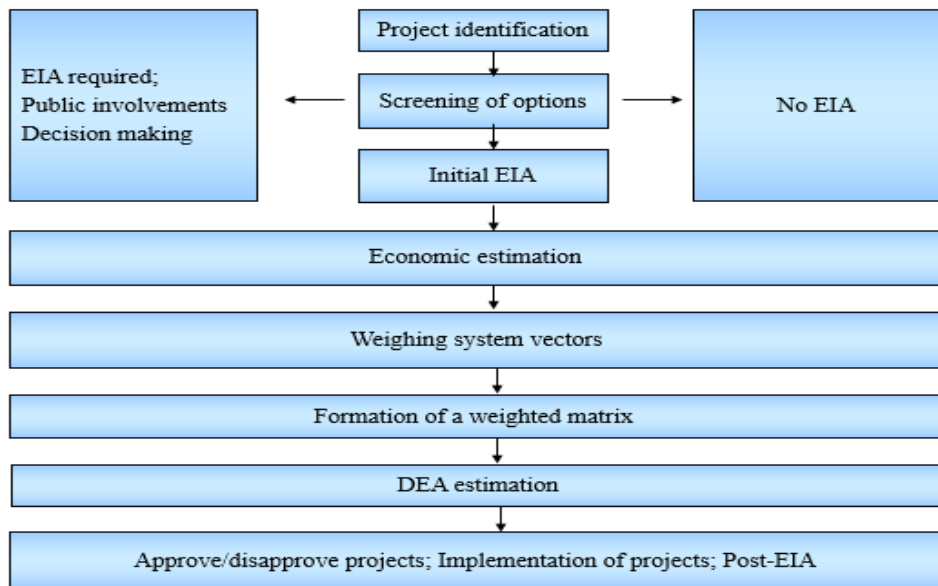


Figure 1. The evaluation steps of EIA in Iran and procedure conducted

3.2. Weighing system of Friedman test

When the normal distribution of groups is individually uncertain for us, we use the Friedman test as one of its essential applications. The blocks of values in the matrix are independent, and data are non-parametric. It is similar to the F test that indicates the samples of groups allocated together. It is also able to classify groups

hierarchically. The homogeneity of average weights between values in the Friedman test depends on low fluctuations in data introduced into software for further processing (Biju and Prashanth, 2017; Eisinga et al., 2017). The existing Friedman test in the SPSS software was used to estimate the values of weights in the present study. There are a few empirical equations to describe the method, but this research has ignored to include them.

3.3. Weighing system of CRITIC

The use of the weighing system of CRITIC is encouraging because of its wide application in studies. It is classified in the list of correlation methods. The criterion X_{ij} consists of the membership function r_{ij} , which converts the existing quantities into an interval [1-0] to present the ideal point. The data matrix is configured with elements of r_{ij} with a standard deviation (σ_j) for the individual vector after translating the initial values. The values of weights are calculated for the assumed criteria by values of C_j (Vujicic et al., 2017).

$$r_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \quad (1)$$

$$C_j = \sigma_j \sum_{j=1}^m (1 - r_{ij}) \quad (2)$$

$$W_j = \frac{C_j}{\sum_{j=1}^m C_j} \quad (3)$$

3.4. Traditional DEA model

The main application of the DEA model relies on distinguishing the efficient and inefficient alternatives (industries in this research). The framework of the DEA model has been defined based on the division of the sum of weighted outputs variables to the sum of weighted inputs variables according to equation 4. The inputs and outputs variables were the costs of materials, the salary of employees, energy consumed, and industries' products for five industries in the present study, respectively. The vectors of both weighing systems of Friedman test and CRITIC were introduced into a matrix of data to sum the final values as productivity of alternatives. Then the maximum value of productivity was selected to release the efficiency score (Sergi et al., 2020).

$$E_{kk} = \frac{\sum_{r=1}^s U_{rk} Y_{rk}}{\sum_{i=1}^m V_{ik} X_{ik}} \quad (4)$$

Regarding an allocation of n DMUs (alternatives) to be investigated, and individual DMU j ($j=1, \dots, n$) generates s various outputs via applying m different inputs, which are realized as Y_{rj} ($r = 1, \dots, s$) and X_{ij} ($i = 1, \dots, m$) respectively. To find out the efficiency (E) score of DMU k needs a division of the weighted sum of outputs over the weighted sum of inputs according to equation 4. By the way, $V_k = (V_{1k}, \dots,$

V_{mk}) and $U_k = (U_{1k}, \dots, U_{sk})$ are input and output weighing vectors to evaluate DMU k , as U_{rk} and V_{ik} are multipliers of the inputs and outputs, respectively (Vujicic et al., 2017; Hassanpour, 2020).

4. Result and discussion

To start describing the applied processes in five generation and regeneration industries (Drip irrigation system, Mobile sprinkler for the home lawn, PVC film generation, cardboard generation of agricultural waste, and plastic waste recycling industries), was displayed their flow diagrams as below (Figures 1.1 to 1.5).

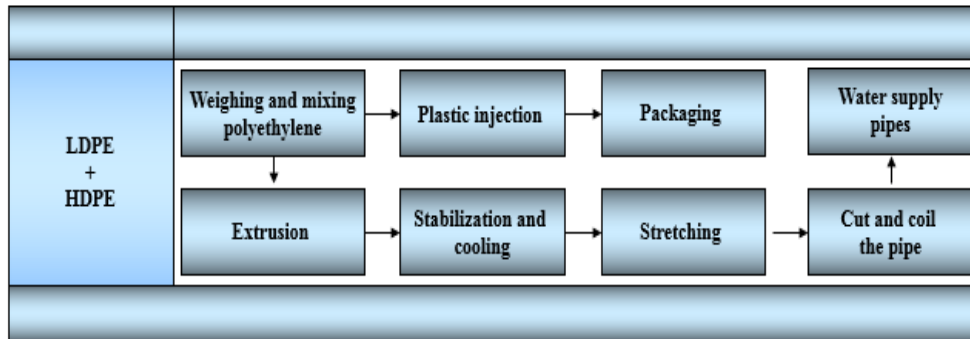


Figure 1.1. Diagram of layout units of drip irrigation system manufacturing in Iran

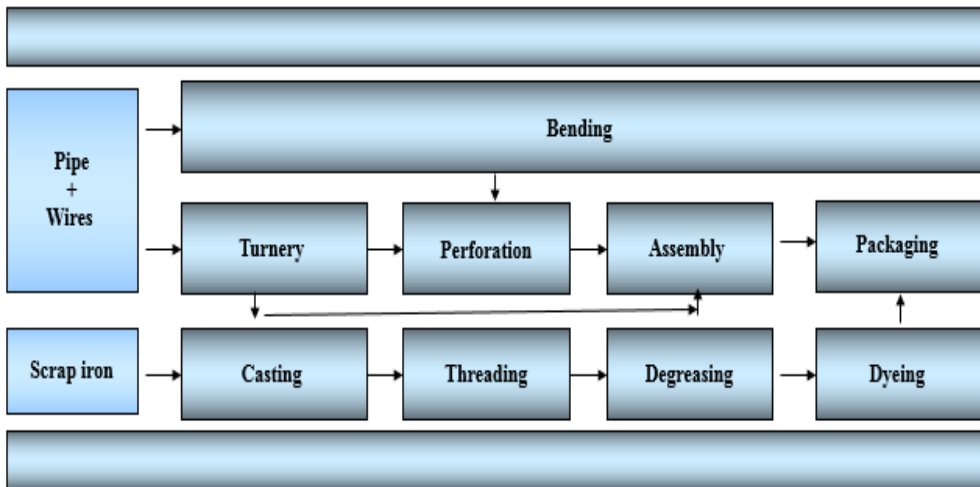


Figure 1.2. Diagram of layout units of mobile sprinkler generation industry for the home lawn in Iran

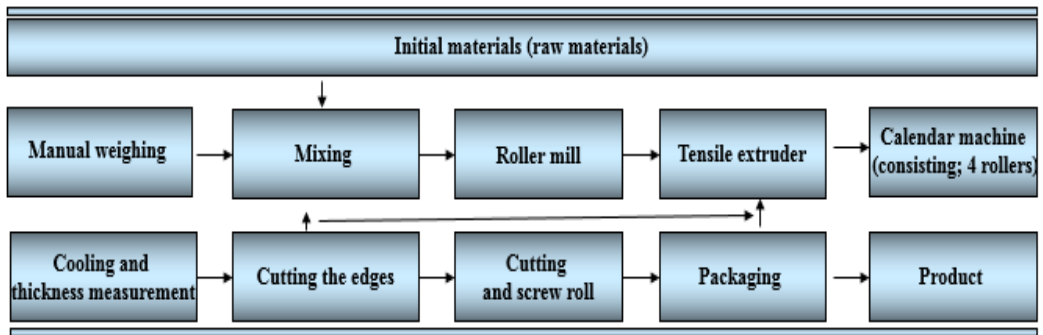


Figure 1.3. Diagram of layout units of PVC film generation industry for the agricultural use in Iran

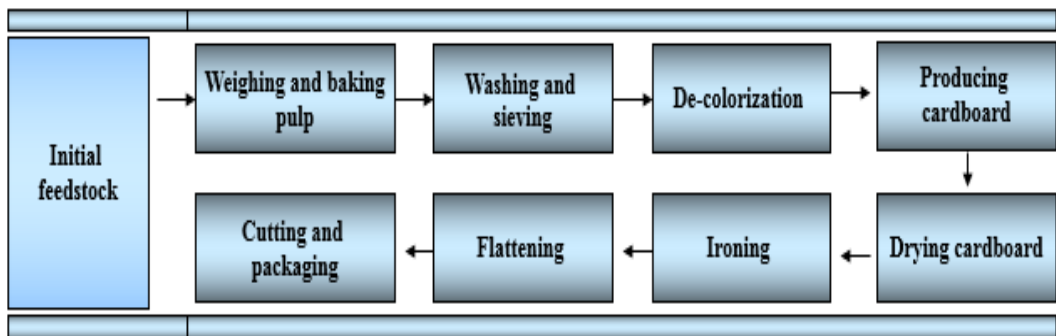


Figure 1.4. The steps of cardboard generation of agricultural waste

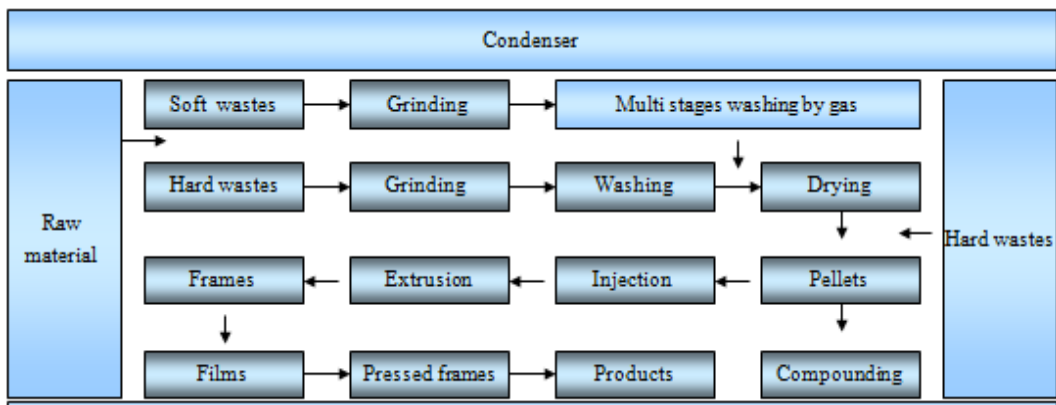


Figure 1.5. The layout units of recycling of the plastic wastes

4.1. Drip Irrigation System Manufacturing Industry (DISMI)

In a drip irrigation system, the required water is transferred to the plants through a pipe and passing through different device components. This system typically includes a motor pump, a cyclone, a sand filter, a fertilizer tank, a control center, an optical filter, the main pipe, a water pipe, and a dripper. Its wide application is for farms, gardens, and greenhouses. The production steps of drip irrigation components (pipes and dripper) are as follows: (1) Polyethylene and additive materials are weighed and mixed in a blender (2) The output mixture enters into the extruder and takes the desired shape when it is leaving the extruder. (3) The pipe enters into the stabilizing bath, which is closed, and its pressure by the vacuum pump is slightly less than the atmospheric pressure. After leaving the tub, the pipes enter into the cold water. (4) This unit has two rows of conveyor-like plastic strips, placed at the bottom and top of the pipe, and pull it with friction force so that the pipe does not wrap after leaving the mold. (5) The pipe is cut to the desired length with a circular saw. When the pipe is cut, the saw moves with high speed in the direction of the pipe. After cutting, the tubes are assembled on the spool. (6) The impeller is made of plastic. (7) Each of the 22 emitters is placed in a cardboard box in dimensions of 200 cm³, according to Figure 1.1. The annual requirements of DISMI have displayed in Table 1.

Table 1. Annual requirements of DISMI (nominal capacity 1000 No+383.9t)

The materials and equipment	Total annual rates	\$
Materials demands		
HDPE	173t	204998
LDPE	224t	
Pigment with the soot of 40%	16.600t	
Single-layer of cardboard boxes	31250 No	
Products		
Dripper (according to standard 8072 and 8074 DIN);	1000 No; 233.37t;	4830572
Water supply pipe with a tolerable pressure of 10 atmospheres made of LDPE, heat resistance up to 80 and withstand cold up to -70 Ć with specific characteristics in the national standards of Iran, numbers 1331;	150.56t	
Water supply pipe with a tolerable pressure of 110 atmospheres and made of HDPE, heat resistance up to 80 and withstand cold up to (-70) Ć with specific characteristics in the national standards of Iran, numbers 1331 and 2178		
Employees		
Staff	52 persons	83200
Energy consumption		
Required water	4590 m ³	21062
Power consumed	47520 kW	
Required fuel (Stoves)	1350 Giga joule	

4.2. Mobile sprinkler for home lawn

The home lawn sprinkler is a mobile piece and works with municipal water pressure, and is used to irrigate lawns and gardens to a limited extent. The sprinkler is classified as all-metal, all-plastic, and semi-plastic, which in this design, the type of semi-plastic was selected. It is made of cast iron in base and elbow, an aluminum fountain, and a plastic hose. It is designed in such a way that the fountain with water pressure in addition to spraying water in droplets, rotates around, and the elbow provides the possibility of irrigation under the beam. The stages of production of grass sprinklers are as follows: (1) Lathing: The parts of the sprinkler mold, which are made of hexagonal profiles, wire, and aluminum pipes, are threaded according to the necessary processes of the lathing, drilling, and incorporating steps. (2) Bending: The aluminum fountain tube will require a superior bending to perform the mechanism of circulation with underwater pressure where manual bending is used. (3) Drilling: Fountain pipe and cap need holes for spraying water, which is used to make a hole. (4) Assembly of sprinkler parts: First, the cap is screwed on the fountain pipe, and then the pipes are closed inside the revolving base and then the feeder base and ribbed seal are installed on the revolving base. (5) Casting: Scrap iron is used for the production of the base of cast iron and elbow as a melting process which is prepared by a furnace and a mold. (6) The threading of the base and the elbow for installing the fountain is created in the product by a lathe. (7) The base and the elbow are degreased to be ready for dyeing. (8) Dyeing is done with a pistol. (9) Packaging: The last stage of production is the packaging of three sets of sprinklers, elbow base, and hose head inside the plastic and cardboard boxes, according to Figure 1.2. The annual requirements of mobile sprinkler generation industries for the home lawn applications have displayed in Table 2.

Table 2. Annual requirements of mobile sprinkler generation industries for a home lawn application (nominal capacity of 81000 No)

The materials and equipment	Total annual rates	\$
Materials demands		
Scrap metals	26700 kg	15000
Al wires, d=20 mm	290 kg	
Al pipes, d=22 mm	290 kg	
Hexagonal Al	6100 kg	
Al pipes	4700 kg	
Al wire	1t	
Plastic labels	81000 No	
Dye	3120 kg	
Cardboard boxes 10*15*15 cm ³	81000 No	
Nylon bags	81000 No	
Packaging carton in sizes of 45*45*50 mm ³	1800 No	
Plastic pipe heads	81000 No	
Plastic washer, external d= 19 mm	81000 No	
Steel washer, internal d= 21 mm	81000 No	
Products		
A mobile sprinkler which works with municipal water pressure, with a fountain made of AL, and a plastic hose head. It has good resistance to water in terms of erosion	81000 No	81000

and abrasion.		
Employees		
Staff	9 persons	14400
Energy consumption		
Required water	1620 m ³	7439.3
Power consumed	14040 kW	
Required fuel (Stoves)	2160 Giga joule	

4.3. PVC film for agricultural use

The steps for generating the PVC films in agricultural use are explained in the following (1) Raw materials are weighed in proportion to the required. (2) These required PVC materials, emollients, and other additives which are required for mixing are introduced into the mixer. To achieve uniformity, the mixture is vigorously re-mixed by transferring into a strong mixer. (3) The mixture is conducted by a conveyor to a two-roller mill to perform another stage of mixing. The mixture is fed to the secondary two-roller mill to re-mix the constituents. (4) The mixed material is disembogued to the extruder. (5) Using a conveyor belt, the mixture is transferred into a cylinder consisting of 4 rollers to bring the thickness to the dimensions referred as PVC film. (6) The temperature of the PVC film is reduced by passing through the dryer. The thickness of the PVC film is estimated via a measuring device which works based on beta rays. (7) For the PVC film to be rolled in terms of dimensions, its sides are cut, and its waste is returned to the initial mill. (8) PVC film is wrapped in a roll using the machine and the desired length. (9) The resulting rolls are packed using Kraft paper, according to Figure 1.3. The annual requirements of PVC film generation industries for agricultural use have displayed in Table 3.

Table 3. Annual requirements of PVC film generation industries for agricultural use in Iran (nominal capacity 21600000 m²)

The materials and equipment	Total annual rates	\$
Materials demands		
PVC	3672t	416834.3
Shaping materials	55t	
Stabilizer	73t	
Additives	37t	
Paper in sizes of 0.5*2 m for packaging purposes	220000 No	
Products		
PVC film, width = 1.8 m, thickness = 0.5-0.1 mm, the average weight of each m ² of PVC film = 92 g, the weight of each meter of PVC film = 170 g	21600000 m ²	7714285.714
Employees		
Staff	46 persons	73600
Energy consumption		
Required water	270 m ³	1708.5
Power consumed	55620 kW	
Required fuel (Stoves)	27270 Giga joule	

4.4. Cardboard generation of agricultural waste

Cardboard is a type of plywood that, due to the required strength and flexibility, is mainly used in the packaging industry, and each square meter should consist of more than 180 grams. The process of producing cardboard from agricultural waste is explained. (1) Weighing: Raw materials (agricultural waste and chemicals) are weighed to a certain proportion. (2) Baking pulp: Chemicals with agricultural waste are placed in a baking dick and are prepared at a lower temperature of 100 °C (3) Washing the pulp: The pulp is coming out of the cooking pot is washed with water inside a washing cylinder in three steps. (4) Sieving the pulp: After mixing and diluting, the clean pulp is pumped to centrifugal filters, and heavier particles like sands are separated from the pulp. The dryness percentage of the pulp is increased to about 100% by the thickening system. (5) De-colorization system: The pulp is mixed with chlorine solution in a blender with a retention time of 45 minutes. Then it is conducted to the chlorine washing system. After re-dilution with hypochlorite solution, it is transferred to the final rinse and is transferred to the cardboard-making machine in several stages of de-colorization. (6) Cardboard making: After passing through the de-colorization system, the paste is transferred to the cardboard making machine by a pump, and after withstanding the hammer pressures for separating the water from the suction pulp, it is sent to the drying part. (7) Dryer: After the pulp passes through the cardboard-making machine, it is sent to the dryer tunnel, and inside this tunnel, hot air hits the cardboard and makes the cardboard to be dried. (8) Ironing: since the cardboard loses its smoothness after leaving the dryer and its surface becomes uneven, in addition to flattening the surfaces by ironing with the pressure, it compresses the fibers and increases the strength of the cardboard. (9) Cardboard cutting: After ironing the cardboard, the cardboard's dimensions are equalized by the cutting machine, and it reaches the desired dimensions. (10) Packing: 100 pieces of cardboard are cut (80 by 120 cm²) and placed inside the packing plastics. The annual requirements of cardboard generation industries of agricultural waste have displayed in Table 4.

Table 4. Annual requirements of cardboard generation of agricultural waste (nominal capacity of 1350 Kg)

The materials and equipment	Total annual rates	\$
Materials demands		
Agricultural waste	2700t	111926.22
NaOH	10800 kg	
NaCO ₃	5400 kg	
Hypochlorite sodium	5400 kg	
LDPE	44400 m ²	
Products		
The cardboard consists of 50-90% cellulose according to Iranian standard number 1411	1350t	1400000
Employees		
Staff	46 persons	73600
Energy consumption		
Required water	9180 m ³	42170
Power consumed	85320 kW	
Required fuel (Stoves)	11070 Giga joule	

4.5. Plastic waste recycling industries

The steps for recovering plastic waste are as follows (1) Waste classification: After collection, plastic waste should be classified according to the type of materials such as polypropylene and polyethylene, softness, and hardness. (2) Crushing and grinding the scrapes in less than one inch. (3) Washing: Particles can be cleaned in water washing machines. It can be used either the sodium carbonate or ordinary detergent powders for this purpose. (4) Dehydration and drying in a heated oven. (5) Granulation: To prepare the pellets of plastic particles to use in downstream processes or to mix with first-hand materials, clean pellets of plastic particles must be in the form of granules, according to figure 1.5. The annual requirements of plastic waste recycling industries of agricultural waste have displayed in Table 5.

Table 5. Requirements of the plastic wastes recycling industry

The materials and equipment	Total annual rates	\$
Materials demands		
LDPE	1000t	108571.43
NaCO ₃ (0.5 g per kg wastes)	0.5t	
Products		
Granules of LDPE + LDPE milled	230t+400t	878787
Employees		
Staff	9 persons	14400
Energy consumption		
Required water	1620 m ³	7743
Power consumed	91530 kW	
Required fuel (Stoves)	2430 Giga joule	

4.6. DEA assessment

The Friedman test was used to calculate the weights of criteria along with the weighing system of CRITIC. According to the t-test analysis, there is no significant difference between the obtained weights in both systems. Table 6 shows the values of weights in weighing systems.

Table 6. The values of weights in weighing systems

Industries/criteria	Materials demand	Products	Employees	Energy consumption
Friedman test				
W _j	3	4	2	1
Weighing system of CRITIC				
W _j	0.044233462	0.943349249	0.007437201	0.004980089

According to Table 7, the obtained results in the DEA score consist of a range between zero to one for the inefficient to efficient borders respectively. The number 1 denotes the fact that the industry is working with top efficiency and below that goes far from the efficiency border. The less value in the DEA score, the less efficiency will have emerged.

Table 7. DEA score and rank

Industries/criteria	Productivity	DEA score	DEA rank
Based on the Friedman test			
(1)	24.07893766	1	1
(2)	3.988217525	0.165630959	5
(3)	22.05008681	0.915741679	2
(4)	10.66364713	0.442862026	3
(5)	9.703456899	0.402985258	4
Based on the CRITIC system			
(1)	465.4	1	1
(2)	94.6	0.203288049	5
(3)	383.137	0.823245193	2
(4)	231.364	0.497131417	3
(5)	167.538	0.359988748	4

Drip irrigation system (1), Sprinkler generation (2), PVC film generation (3), Cardboard generation of agricultural waste (4), Plastic wastes recycling (5)

The t-test analysis had shown a significant difference ($p\text{-value} \leq 0.028$) for the criterion of employees in comparison with other variables (criteria) such as materials demand, product, and energy consumption. The null hypothesis test summary via a one-sample Kolmogorov Smirnov test retained the null hypothesis for the variables. But the same hypothesis had revealed a significant difference around 0.002 among four variables via related samples Friedman's two-way analysis of variance by ranks and the distribution of materials demand, product, employee, and energy consumption was the same.

Due to a significant rise in the price of raw materials required by industries, dependence on procuring raw materials of industries (in many cases), and devaluation of the Iranian currency, there is a need for a significant rise in the price of industrial products. On the other hand, due to the decrease in purchasing power, the industries will move towards inefficiency. With a slight increase in the selling price of the products of the industries, the efficiency score will decrease too. Also, with the rise in employees' salaries in the industry, there will be a further decrease in efficiency of industries. So, the stakeholders tend to either reduce the salaries of employees or lay off the number of employees. Due to the variability in energy consumption in units with the same nominal capacity, the results are not comparable to operating companies. Because the initial estimates in the project screening phase will change with the pattern of energy consumption in the industry after the construction of the industries. The quantity of energy consumption can be the same, but the costs will vary depending on the type of energy applied. On the other hand, finding industries with the exact specifications will raise the lack of cooperation from managers. To prove the fall and rise in efficiency score of industries before and during the period of sanction we can only rely on reports of inflation rate in Iran. The inflation rate and the rise in the price of goods are monthly announced by the in-charge bodies in Iran. To estimate the efficiency score of industries was used real data. Conducting a sensitivity analysis via manipulated and sophisticated data for the costs of energy & materials streams before and during the period of sanction will make the real results meaningless. The other limitations of the present research refer to the provision of initial data, the collaboration of in-charge organizations with the

research centers, fluctuations in the market for the costs of materials & energy demands in industries, and raising the daily prices.

5. Conclusion

The present research attempted to find the efficiency of 5 industries based on the input variables of materials demand, employees' number, energy consumed, and the output variable of products generated. The DEA method applies to industries with the same nominal capacity. It can allocate them in a particular decision-making situation concerning the fact that the whole inventory of availability is the same for them in the screening step. But the efficiency will be changed for the same industries with different nominal capacities. It means by assessing an industry from one particular group, we can decide for the same group of industries with the same nominal capacity. On the other hand, we are aware the running technologies are the same among certain groups and stakeholders used the same processes and technologies in their manufacturing units in Iran. Any development and progress will happen in the post-EIA after the complete establishment of industries, and the efficiency will change according to a rise in the variables interfering in DEA estimation and during a time interval (years) of operation. However, it needs to point out that due to the ongoing pandemic prevalence of Covid-19 in our world, the efficiency scores of all sectors are decreasing. This situation is valid for the global economy. This fact should be taken into account as well as the current situation in Iran.

Future studies can be discussed for changing the actual prices of input and output variables and can be compared with existing reports to find the significant differences and conduct a sensitivity analysis in a variety of scenarios. Using novel models of DEA either individually or integrated with other multi-criteria decision-making models is also encouraging to find efficient enterprises. The tabulated data can be used to estimate the financial statements of mentioned industries and develop any financial estimation model in this regard. Also, the sustainability of industries can be taken into consideration by selecting various criteria from concepts presented by the text in decision-making theory.

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