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RESEARCH PAPER

Techno-economic assessment model of screening step of agricultural wastes recycling to animal feed project

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Highlights

- The tabulated data picked up from the initial screening step of project identification in Environmental Impact Assessment (EIA).
- EIA plan has been defined based on materials and energy streams assessment along with an inventory of equipment and facilities for screening step by Iranian evaluator team.
- The tabulated data followed a connection between equations and inventory of availability to underpin the framework of an economic assessment model that is able to extend for any engineering and industrial project.

Graphical Abstract

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Abstract

Agricultural wastes seem to be a valuable resource of revenue for nations and serious wastage of resources by refusing and ending up in the environment. Nowadays, lots of nations encouraged to implement industries for managing and recycling waste materials and generate animal feed. According to the Environmental Impact Assessment (EIA) plan set by ruling organizations, industrial projects must be undergone the required assessment. The present study took the opportunity to offer an economic assessment model for the following aims of EIA in parallel with the sustainability of industrial projects. The technical assessment of the project has been underpinned based on the initial screening of the Iranian evaluator team. Initial data belongs to both the Iranian environment protection agency and Iranian industries organization in the screening step of EIA. The findings empirically suggested a model to investigate the economic statement of projects in EIA. The developed model considered an economic framework for equipment and installation costs, materials costs, facilities costs, transportation costs, employee's costs, energy consumption costs, required land and landscaping costs and discussed the methods to figure out the fixed capital wage cost, interest rate, annuity factor, total annual costs, cost of facilities replacement, cost of manufacturing, and annual depreciation costs. It can be concluded that the tabulated data can be extended for any project and in the developed model will be replaced new equations depend on project expansion. But the framework of the table and its connection with the economic equations will remain constant for any industrial and engineering project.

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1. Introduction

In general, most of the costs of the livestock industry are related to animal feed in the world. On the other hand, having good quality animal feed throughout the year is another major limitation of the livestock industry. Biological constraints, environmental and economic benefits in livestock production have led to the reuse of recyclable agricultural products. Using animal waste, summer crops and fruits in animal and poultry nutrition is valuable for generating indirect food from a lot of waste stream (Okine, 2007).

Processes on industrial and agricultural wastes can be entered into the primary (crop production) or secondary (livestock feed) cycles. Processing and using these wastes to prevent environmental pollution, impede wasting nutrients and seems very reasonable (Ullah, 2014). Processes on waste for generating the animal feed mainly result in, digestibility, feed efficiency, and daily weight gain and its rise. The presence of nutrients in the municipal, industrial, and agricultural wastes can be used to produce organic fertilizers and animal feed. Although these materials contain anti-nutritional and heavy elements but can be recycled by performing various physical, chemical, and biological processes. In general, the application of the process to convert waste, in addition to enhancing feed quality, must also consider the economic value of these methods and their usefulness. Animal feed is said to be digestible and absorbable matter and is used by the animal after it is eaten. But in general, the food contains nutrients although not fully absorbable, since one type of food cannot meet all the animal's needs, a variety of different foods are combined and given to the animal. This compound is called animal feed. Given that most of the livestock sector in Iran is exporting crops such as corn, soybean meal, and animal feed, the conversion of agricultural waste to animal feed can create high added value. Nowadays, with the industrialization of livestock, poultry and aquaculture, and extensive studies on circumstances of growing and managing farms, it has been concluded that proper feed in addition to increasing animal productivity reduces the current costs of a unit such as energy consumption for heating and fighting against a variety of internal and external diseases. In other words, if the animal receives adequate nutrition in terms of its energy, protein, minerals, and vitamins, it can withstand a large number of diseases and harsh environmental conditions and produces good yields. Optimal use of agricultural waste avoids environmental problems and reduces forage prices, impede culminating wastage and waste disposal of industries which are currently set up in three provinces of Iran, such as Semnan, Kerman, and Yazd. Iran produces over 5 million tones of agricultural waste every year. It is also possible to produce forage and reduce the cost of production operation using fermentation and silage techniques. The plan to use crop residues for forage production is one of the important projects in the field of agriculture that has significant economic benefits. Most ranchers have traditionally used agricultural waste for forage, but for producing an animal feed of agricultural waste, steps must be taken to prevent forage spoilage, increasing the yield of plant residues in meat, milk, and egg production. Collecting, processing, and removing agricultural and plant wastes are the knowledge that is applied in forage production centers and high-efficient forage is produced and stored. In the field of agriculture, the plan to use crop residues for forage production is one of the most important economically viable projects (Mehrdad et al., 2014).

In China, the rapid growth of agricultural waste led the organizations to encourage stockholders for recycling the materials and they also asked the government's attention for further progress and development platforms in its management (Wang et al., 2016; Chernyaeva and Teng, 2017). The disposal of agricultural wastes is among the country's environmental problems such as incineration, release into the environment, burial, and refusal of agricultural wastes. A huge quantity of budget is spent in the country to produce agricultural products annually. About 30 to 35% of these products are discarded annually and the extra money will be spent on collecting and disposing of these wastes, which in any case will cause irreparable damage to the living environment. If most of these wastes are recyclable with proper investment, not only it is possible to prevent further damage to the environment, but also the amount of human need reduces primarily and is harvested of both natural and mineral resources and ensures its survival for future generations. The typical management practices of agricultural wastes comprised methods such as organic cultivation, animal feed generation, bioethanol generation, compost processing, petroleum-free mulch generation, materials conversion technologies, and biogas generation, etc.

Matter exists in different states in nature and when it has enough energy, it changes from one state to another. In general, plasma, with its energetic and active atoms, molecules, ions, and electrons, can change its properties by the interaction of various materials, including biomaterials, liquids, and solids, and is the source of a wide range of applications in various industries. Different types of plasmas are used in a variety of applications and their parameters vary according to the application in each field. In the chemical industry, the importance of plasmas is in the decomposition of gases (for example, the removal of hydrocarbons) and in helping to produce gaseous fuels containing hydrogen and carbon monoxide. There are many reactors designed in this field with different capabilities (Peters, 1959). With the huge quantities of energy consumption and increasing concerns about environmental issues and pollutants culmination, the production of hydrogen-rich gas (as a clean and efficient energy source) and the conversion of hydrocarbon fuels heavier than methane and methanol requires newer technologies and developments. Cleaner and more efficient energy generation systems have become more important. Today, these processes are performed using catalysts, which often respond slowly and are expensive. Electric discharge plasma technology is a reliable technology in this situation. Electric arc plasma has many potential applications in agriculture. These applications include sterilizing seeds during storage, increasing seed germination, adding reactive oxygen species and other oxidants along with lowering the pH to reduce the invasion of soil pathogens, cleaning the air, sterilizing and removing organic compounds, removal from greenhouse gasses, and disinfection of products before packaging, air cleaning, sterilization and removal of organic compounds, disinfection of products in the packaging process in storage and transportation facilities, control of pests and pathogens in stores and storage places, removal of ethylene from the air (to increase the time of aging), sterile cutting boards, knives, and food processing equipment, disposal of hazardous waste or conversion of waste into energy and non-hazardous waste and reduction of microbial mass of distillates, etc. The gasification operation of plasma reactors also plays a very important role in converting many agricultural wastes into gaseous products, fuels, and ethanol. Gaseous products in the exposure to water lead to the generation of useful products with high added value. All the mentioned practices follow the aims of sustainable development (Kummu et al., 2012; Wagner, 1999).

A huge quantity of agricultural products goes out of the generation cycle between cultivating and harvesting periods. According to reports around 35% of agricultural products are disposed into the environment as waste materials. It comprises about 15 to 20 million of Iranian inhabitant's food stock. Agricultural waste disposed of in the environment is a good substrate for fire production and can cause serious damage to ecosystems, ecology, and the environment. This endangers the lives of many living microorganisms, fauna, and birds and leads to the extinction of wildlife. The food supply chain also poses a serious threat to organisms. Air pollution and soil erosion will also be the next problems. Therefore, the management of this waste will help to preserve the environment (Obi et al., 2016).

The regulation and rules of agricultural waste management approved by the Iranian Environment Protection Agency, the Ministry of Agricultural and the National Waste Management Working Group sought certain objectives such as (1) Maintaining public health and the environment protection against the adverse effects of agricultural waste (2) Increasing productivity in the agricultural sector and reducing the production of agricultural waste and reusing wastes (3) Apply new methods of agricultural waste management (4) Ensuring proper and relevant executive management programs (5) Establishing an appropriate and regulatory procedure for agricultural waste management.

In Iran, the cost of feeding livestock and poultry accounts for about 70% of the cost of breeding animals and on the other hand due to lack of food and livestock feed in the country; millions of dollars are spent on imports of raw materials annually. It is worthwhile to take appropriate measures and plans to use the waste of agricultural products in animal feed, poultry, and aquaculture. Also, the study of economic models of agricultural waste recycling factories is considered as one of the main needs and goals of the project and present study (Toop et al., 2017). Therefore, the present study took into consideration the techno-economic assessment model in the screening step of agricultural waste recycling to animal feed project by pointing out the requirements and initial costs and in the following section by extending the model to other financial statements.

The techno-economic performance of cotton cropping systems performed depend on data collected from 169 farmers in the southern part of the Punjab, Pakistan. Cost efficiency differences revealed across different farms statistically significant at 10% along with no eco-efficiency per kilogram of seed cotton (Okine, 2007). The capital costs, fixed operating expenses, variable operating expenses, income tax, revenue from fuels, gasoline, recyclable scrap and revenue from other co-products calculated by simple cost collection of materials in the environmental and economic assessment of transportation fuels from the municipal solid waste. The cost of energy, cost of raw materials, operating cost of amine recovery unit, total operating cost, fixed capital cost, annual sales of product and economic gross potential have been taken into consideration in a techno-economic assessment of ethylene technologies (Thiruvenkataswamy et al., 2016). The costs paid for staff, total operating cost, operating and maintenance costs for various capacities, electricity selling price and gate fee, landfill disposal fees, maintenance cost, fixed and variable transportation cost and Inflation rate were taken into account in the techno-economic and the utilization of food processing waste for energy production was also evaluated (Ullah, 2017). Also, a sensitivity analysis conducted based on initial costs and new costs. By the way, the fall and rise in prices have been taken into consideration in the outlays. The economic and environmental performance of micro-algal processes has been investigated based on a stream of input factors (such as costs of greenhouse gas emissions, energy demand, and minimum selling price) by a techno-economic model in a simple calculation of outlays (Pérez-López et al., 2018).

Techno-economic assessment of fast pyrolysis for the valorization of short rotation coppice cultivated for phytoextraction has been done regarding the parameters of energy consumed, percentage of delivered equipment cost, operation and pyrolysis costs, biomass purchase, pre-treatment costs, labor, and staff salary, transport costs, landfill costs of char and maintenance costs (Kuppens et al., 2015). The multi-objective mathematical programming model has been employed to conjoin the frameworks of sustainability regarding the outlays of the supply chain. The developed model offered a connection between sections of sustainability with a strong base in the management aspect. The connection loop comprised rings of factories and warehouses; warehouses and customers; customers and warehouses; warehouses and factories (Mota et al., 2015). The agricultural waste recycling as a viable process in aim of the circular economy was evaluated, so that waste reduction and making the best way to reuse the valuable waste stream refused (Toop et al., 2017). To declare the objective of the current study corresponding author used 3 different economic models for estimating the outlays of the various projects in EIA such as plastic waste recycling, silver recycling of photography wastes, recycling of sludge in making brick, used motor oil recycling and acidic sludge recycling of reprocessing industries, etc. The availability of waste bio-refineries in the national development in terms of waste disposal challenges, fuel consumption simplicity, power, heat existence, and value-added commodities, was examined (Nizami et al., 2017). So, the study compared the running technologies by techno-economic assessments. The Caprolactone generation from agricultural residue has been scrutinized by materials, energy stream and outlays along with greenhouse gasses decline via an economic model. A sensitivity analysis has been done to compare the fluctuations in expenses in the second step (Thaore et al., 2018). The techno-economic feasibility of commercial-scale and solid-state anaerobic digestion and composting systems (20,000 metric tones per year) investigated to accommodate both outlays of yard trimmings and anaerobic digestion effluent via a model for calculating revenues, capital cost, operating cost, payback time, internal rate of return, and net present value (Lin et al., 2019).

Techno-economic and environmental assessment of milking of microalgae for renewable hydrocarbon production carried out considering the rate of return, the number of operating labor, energy consumption, return on investment, energy and the material balance consists of lots of equations to estimate (Chaudry, 2018). A sensitivity analysis has performed to compare the expenses. Phthalic anhydride is widely applied in the plastics industry, resins production, agricultural fungicides, and making up amines, etc. It can be generated from an agricultural residue (i.e. corn stover). Therefore, it takes into consideration the techno-economic assessment of energy equalization alternatives in parallel with water usage, and the life cycle assessment of greenhouse gasses' dissipation (Giarola et al., 2016). The gasification operation of refuse-derived fuel has been experimentally run. Modeling has been proposed regarding the parameters of Investment, operation and maintenance costs, equipment depreciation costs and contingency and fees (Násner et al., 2017). The energy and economic evaluation of gas and electricity generation using municipal solid waste with regard to the annual operation and maintenance outlays and capital costs of existing technologies in this regard, was conducted (Silverman et al., 2020). By the way, the outlays tabulated and shifted to currency. The annual operating cost, present value, net present value, revenue, production, and levelised costs and scaled cost took into account in the techno-economic assessment of direct methanation of biodiesel waste glycerol (White, 2018). Processing of manure to generate organic fertilizer by granulation has been completed using a mixed-integer optimization model to estimate the lowest sale price and net present value as an economic assessment model (Sharara et al., 2018).

2. Materials and methods

The present study got the initial data of the assessment from the Iranian evaluator team in the EIA plan. EIA plan forced all industrial projects to go through the initial assessment program once before establishing and constructing industries in Iran. To make a techno-economic assessment, it was tabulated the inventory of requirements in the industry annually. Then, the separate partitions of the model approached to join together. Fig. 1 shows the procedure of the current research in connection with the steps underwent by the assessment of the Iranian evaluator team.

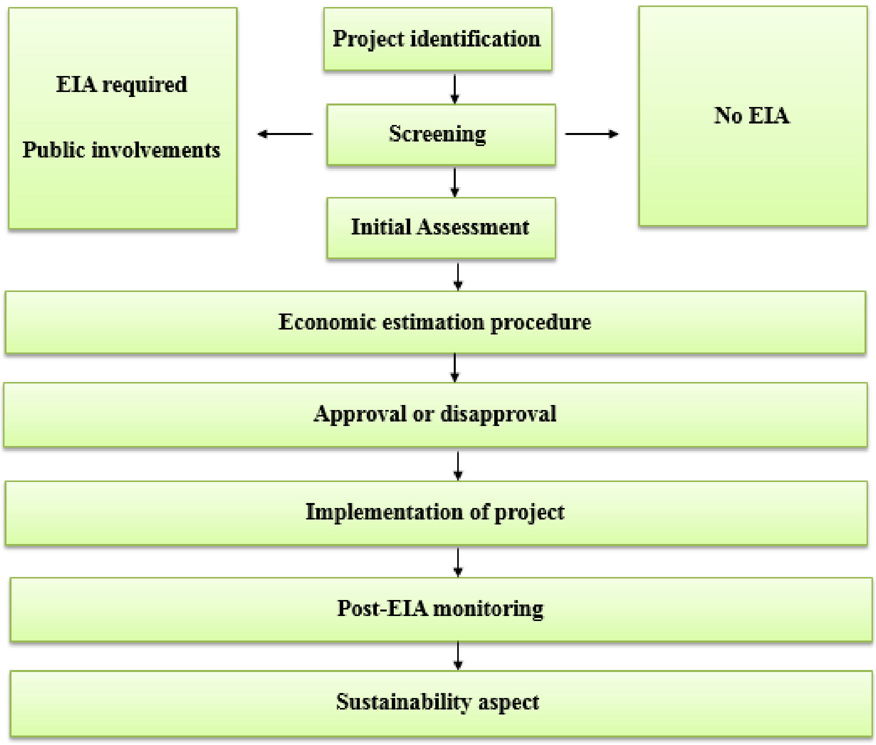

Fig. 1. The evaluation steps of the Iranian evaluator team and followed work for current research.

The screening step of projects includes the total availability and properties of industrial projects. This step underpins the economic and financial estimation required for the projects. The evaluator teams use certain equations to determine the inventory of demands in this field.

3. Results and discussion

3.1. Process features, technical notes, and operating conditions

The main stages of the livestock feed process are farming, purging, grinding, formulation, mixing, pelleting, and packaging which are described at once in each step. Raw materials used for livestock feed consist of three major fine-grained feedstock. Agricultural waste contains flour, dried tea, beet pulp, wheat and barley, olive meal, cottonseed, and soybeans which must be removed by the dewatering machine before entering the production and grinding processes. Dried fodder is another group of raw materials used in animal feed production. They should be crushed first and then can be used. After providing the raw materials needed for the production of animal feed, the process steps will be moved as follows. (1) Winnowing; raw materials like flour, olive and bagasse, meal, dried tea, wheat wastes, and barley will be cleaned before entering the production process. The dust and gravel are first removed by the winnowing machine. (2) Grinding step: for instance, the laying bed of bird's species contains proteins that can be used for livestock, so it is first disinfected and dried before use and then is milled after screening. All of the raw materials mentioned in the first step are also crushed by grinders. Also, forage materials used (such as dried alfalfa) are first crushed and then are milled and used in feed formulation. (3) Formulation stage: The most important step in the production of animal feed is the weighing of raw materials based on the formula provided as it is based on the requirements of the animals. Difficulty in formulation causes nutrients not to reach the body of the animals. At this stage, all the raw materials are prepared and weighted according to the formula and are stored in the tank and top of the mixer. (4) Mixing: At this stage since the density of consumed raw materials varies, so to make a complete mix, all the raw materials available to the livestock are thoroughly mixed in the mixer of raw materials. Transportation operation becomes easier and pellets are stored for longer periods (Fig. 2 displays the steps described).

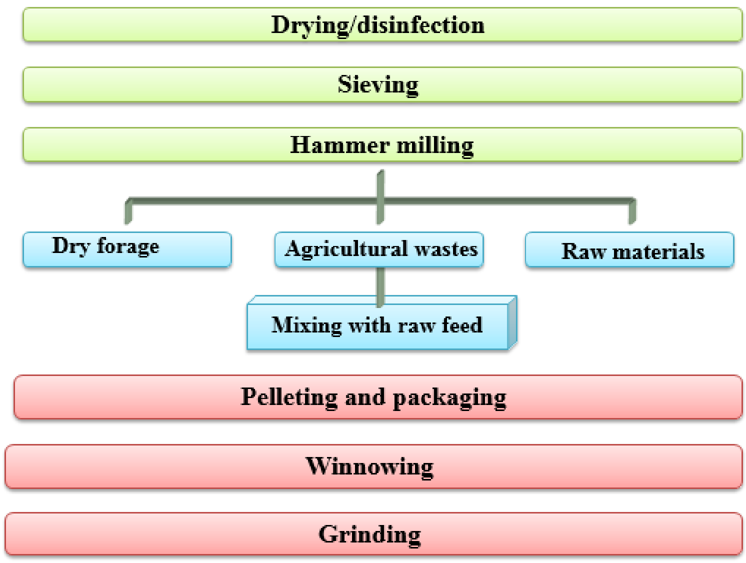

Fig. 2. Agricultural wastes recycling to animal feed.

According to the methodology defined, it was endeavored to tabulate the annual requirements of the project. This is a simple method of sorting and managing data for economic modeling. The requirements have been defined and set pertain to the Nominal Capacity (NC) of industry and with a strong background in the mathematical and experimental equations (Table 1 includes the annual requirements of projects).

3.2. Modeling

By using equations 1 to 7, we can do a simple estimation of requirements by taking into account the outlays for each section in Table 1. Despite the appearance of below equations pretend to offer a simple procedure of economic estimation but having looked at a variety of studies, the procedures have been done regardless to distinguish the sections in the table and recognizing costs separately and not arranged in the classes of equipment, materials, facilities, transportation, energy and land costs.

$$\text{Equipment and the installations costs} = \sum(\$1) \tag{1}$$

$$\text{Materials costs} = \sum(\$2) \tag{2}$$

$$\text{Facilities costs} = \sum(\$3) \tag{3}$$

$$\text{Transportation facilities costs} = \sum(\$4) \tag{4}$$

$$\text{Employees 's costs} = \sum(\$5) \tag{5}$$

$$\text{Energy consumption costs} = \sum(\$6) \tag{6}$$

$$\text{Required land and landscaping costs} = \sum(\$7) \tag{7}$$

Taking out a loan is a common trend for supporting lots of engineering and industrial projects in Iran. The payback time of loans varies including time intervals of a minimum of 6 months to 5 years. For annual wages, loans receive a fixed wage rate of 19% and a working capital wage rate of 22% (applicable in equation 8). The repayment period for fixed capital loans is usually 5 years and loans received to working capital are two years usually. The value at the expense of the fixed capital commission is 60% of the fixed investment.

Fixed investment costs include the cost of land and landscaping, the cost of building investment, and the cost of installing the facilities, the cost of investing in machinery and installation, the cost of investing in purchasing vehicles, unforeseen costs, and pre-operation costs. Taking into account the annual working days to 270 days per year, the outlay of raw materials is stored for 45 days, staff salaries for 68 days, and costs of energy for 65 days will release the value of working capital. Other costs, like sales of manufactured and under manufacturing goods, encompass also 5% of the total cost in Iran (Nizami et al., 2017). The interest rate can be calculated by equation 9. By equations, 9 to 12, i, f, and n are nominal interest rate, annual inflation rate, and expected useful life (year) respectively (Biswas and Kumar, 2017; Egle et al., 2016). So, the mentioned equations can be employed to compute the costs of fixed capital wage, interest rate, annuity factor, total annual cost, and Capital Recover Factor (CFR) as rings of a chain.

$$\text{Fixed Capital Wage Cost} = \frac{values \ \times (time + 1) \times Wage\ rate}{2 \ \times time} \tag{8}$$

$$\text{Interest rate} = \frac{i - f}{1 + f} \tag{9}$$

$$\text{Annuity factor} = \frac{Interest\ rate \ \times (1 + interest\ rate)^n}{(1 + interest\ rate)^n - 1} \tag{10}$$

$$\text{Total annunal cost} = \text{Total cost}/\text{CRF}(\text{j}, \text{T}_\text{p}) \tag{11}$$

$$\text{CRF (i, n)} = \frac{i \ \times (1 + i)^n}{(1 + i)^n - 1} \tag{12}$$

In equation 11 j is the percent of real annual interest rate, Tp is the period of the project, and CRF is the capital recovery factor (Razmjoo et al., 2017).

Cost new, cost°, size new, size°, I, I° and, n are the expense of scaled new equipment, the base equipment cost, the size of new equipment, the size of base equipment, the inflation index of calculated year, the inflation index of the base year and the specific scaling factor for a particular type of equipment ranging from 0.6 to 0.8 in equation 13 respectively (Li et al., 2015). Therefore, any change or replacement in facilities and equipment during the year can be taken into attention by equation 13 in terms of forfeit, compensation, or expansion in outlay.

Table 1. Annual requirements of Agricultural waste recycling project to animal feed (NC of 10000t).

Main annual materials and equipment	Total annual rates	Cost $	Total Cost
Equipment and the installations costs			
Compact compresses of 400 liters per minute	1 No	$\$_1$ [a]	126000
Filling bag with power of 7 tones per hour	2 No		
Floor pellet cooler 5*1	1 No		
Discharge valve	5 No		
Manual pneumatic output valves	4 No		
Balance caps, pre-milling, and mixing, score sheets of degree 3	16 No		
Manual gates	4 No		
Conveyor belt with 20 and 25 blades, score 3 sheets, 3-8 m long and gearbox	8 No		
Elevator with a degree of 20, score sheet of 3 contains gearbox, L= 6 to 10 m	6 No		
Three-floor dryers	1 No		
Winnow machine equipped with gearbox	2 No		
Auger Electromotor holder with a score of 20 and 15	2 No		
Rotary hopper with 3, 5 and 3 degrees, body modules and 3 types of durable, interchangeable blades with discharge underneath	1 No		
Materials costs			
Tea waste	714 tones	$\$_2$	671508.4
Sterile fertilizer	2040 tones		
Wheat bran	2040 tones		
Wheat waste	2040 tones		
Olive waste	714 tones		
Barley	1530 tones		
Beetroot	510 tones		
Supplements	200 tones		
Vitamins and minerals	100 tones		
Straw and dry fodder	300 tones		
Plastic bag	200000 tones		
Beet molasses	550 tones		
Facilities costs			
Fire extinguishers (Total)	70 No	$\$_3$	9032
Stoves (Total)	6 No		
Cooler (Total)	3 No		
Ventilation system (Total)	3 No		
Office equipment, furniture and, etc.	Depends		
Lab equipment (for quality control)	Depends		
Transportation facilities costs			
Transportation (A vehicle, car and etc.)	3 No	$4	24000
Employees' costs			
Staffs salary	23 Persons	$\$_5$	4600
Energy consumption costs			
Required water [(b)]	3000 m^3	$\$_6$	4400
Split AC (Internal wiring, transformers, and emergency power generators)	119700 Kw		
Required fuel (Stoves)	1080 L		
Petroleum expenses (Transportation vehicle and cars)	16200 L		
Required land and landscaping costs			
Required land	9900 m^2	$\$_7$	200000
Construction of infrastructure (Buildings)	2840 m^2		
Pavement and asphalt	6560 m^2		
Landscaping	500 m^2		

[a] Daily price + 5% cost of installation; [b] Initial cost for digging well and its belongings + annual water consumption.

$$\mathrm{COSTnew} = \frac{\mathrm{I}}{\mathrm{I}^{\circ}} \times \mathrm{COST}^{\circ} \times \left[\frac{\mathrm{SIZEnew}}{\mathrm{SIZE}^{\circ}}\right]^{n} \quad (13)$$

$$\mathrm{COM} = 0.28\ \mathrm{FCI} + 2.73\ \mathrm{COL} + 1.23\ (\mathrm{CUT} + \mathrm{CWT} + \mathrm{CRM}) \quad (14)$$

The symbols of equation 14 and 15 are defined as the cost of manufacturing (COM) related to the day-to-day operation, Fixed Capital Investment (FCI), Cost of Labor (COL) regarding the number of operators per shift (NOL) for their annual salary, the Cost of Utilities (CUT= cost of fuels in the processes such as fuel, gas, oil, coal, electric power, steam, cooling, water and refrigeration, etc), the number of processing (P) stages including the handling of particulate, the Number of non-particulate (Nnp) processing steps (the sum of the number of machinery in the plant (i.e. compressors, heaters, reactors, exchangers, etc.), Cost of Waste processing (CWT) and Cost of Raw Materials (CRM) (Cristóbal et al., 2018). Equations 14 and 15 are widely used via procedures in lots of industrial recycling units to estimate the energy and materials consumed specifically, labor expenses, and waste processing costs as alternative and selective equations instead of some equations of 1 to 7.

$$\mathrm{NOL} = (6.29 + 31.7\ \mathrm{P}^2 + 0.23\ \mathrm{Nnp})^{0.5} \quad (15)$$

Financial costs pertain to the values of interest rate (r) and mortgage term (q^n) are defined via equation 16. The quantity of r is fixed to be 5%. The annual installation costs are estimated through the multiplier (k) (Carnevale et al., 2017). To remind, we discussed in the appendix of Table 1 about the cost of equipment installation that was equal to the sum of 5% cost of each piece of equipment. Equation 16 facilitates the way to find the installation costs annually when used a mortgage to purchase any equipment.

$$\mathrm{k} = \frac{(\mathrm{rq}^{n})}{(\mathrm{q}^{n} - 1)} \quad (16)$$

To find the depreciation outlay, we have a variety of coefficients for the facilities, equipment, and construction units annually. In equation 17 annual depreciation (AD) is estimated pertain to the total capital (Y) and the start-up material costs (Msu) with an interest rate (i) of 5% and a payback time (PB). The total annual costs (TAC) are calculated via utilities (U) and materials (m) costs depend on energy consumed and mass balances. Maintenance costs (M) account for a percentage (like 3%) of the total fixed capital costs and the labor costs (L) extracted from the above equation or a percentage around 10% of the Total Annual Costs (TAC) (Fernandez Dacosta, 2018). Annual maintenance outlays in industrial processes are typically assumed for about 2 to 10% of the fixed capital investment. For instance, the annual maintenance outlay for the evaporation station accounted to be 6% of the fixed capital investment.

$$\mathrm{AD} = (\mathrm{Y} + \mathrm{Msu}) \times \frac{\mathrm{i}(1 + \mathrm{interest\ rate})^{\mathrm{PB}}}{(1 + \mathrm{interest\ rate})^{\mathrm{PB}} - 1} \quad (17)$$

$$\mathrm{TAC} = \mathrm{AD} + \mathrm{U} + \mathrm{m} + \mathrm{L} + \mathrm{M} \quad (18)$$

4. Conclusion

EIA is an indispensable program for assessing engineering and industrial projects once before the complete construction of the project. The screening step of EIA provides the platform for developing economic estimation models in the best possible way. Tabulating the costs of the project (properties) is a simple method for developing any economic model in EIA. Depend on the project inventory of availability we can define the loops of different economic models. The developed model comprised a class of economic estimation equations for waste materials recycling plants. The use of the developed models is recommended highly for recycling projects in future researches. Also, it can be deployed to include a variety of economic factors based on the scale of the project. To encompass the costs of public involvement of projects in EIA, future studies can give feedback. The comparison of various equations via following the same objective is also recommended for further developments in this regard. Today, the use of waste materials and its conversion into valuable materials sounds great using plasma technology. Plasma technology can change the phase of materials from solid to gas form to enable the production of many products such as ethanol from agricultural waste, which is in operation in many countries around the world. Gaseous materials are the feedstock and precursors of other products as well.

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References

Biswas, A., Kumar, A., 2017. Techno-Economic Optimization of a Stand-alone PV/PHS/Battery systems for very low load situation. *Int. J. Renew. Energy Res.*, (IJRER), **7**(2), 844-856. ISSN: 13090127

Carnevale, E., Molari, G., Vittuari, M., 2017. Used cooking oils in the biogas chain: a technical and economic assessment. *Energies*, **10**(2), 192. https://doi.org/10.3390/en10020192.

Chaudry, S., 2018. Techno-economic and environmental assessment of milking of microalgae for renewable hydrocarbon production (Doctoral dissertation, Murdoch University). https://doi.org/10.1016/j.wasman.2018.12.037.

Chernyaeva, V.A., Teng, X., 2017. Study of agricultural waste treatment in China and Russia-based on the agriculture environment sustainable development. *In IOP Conference Series: Earth Environ. Sci.*, **69**(1), 012001. https://doi.org/10.1088/1755-1315/69/1/012001

Cristóbal, J., Caldeira, C., Corrado, S., Sala, S., 2018. Techno-economic and profitability analysis of food waste biorefineries at European level. *Bioresour. Technol.*, **259**, 244-252. https://doi.org/10.1016/j.biortech.2018.03.016

Egle, L., Rechberger, H., Krampe, J., Zessner, M., 2016. Phosphorus recovery from municipal wastewater: An integrated comparative technological, environmental and economic assessment of P recovery technologies. *Sci. Total Environ.*, **571**, 522-542. https://doi.org/10.1016/j.scitotenv.2016.07.019

Fernandez Dacosta, C., 2018. Alternative sources of fossil carbon: Ex-ante assessment of novel technologies using waste as a source (Doctoral dissertation, Utrecht University).

Giarola, S., Romain, C., Williams, C.K., Hallett, J.P., Shah, N., 2016. Techno-economic assessment of the production of phthalic anhydride from corn stover. *Chem. Eng. Res. Des.*, **107**, 181-194. https://doi.org/10.1016/j.cherd.2015.10.034

Kummu, M., De Moel, H., Porkka, M., Siebert, S., Varis, O., Ward, P.J., 2012. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Sci. Total Environ.*, **438**, 477-489. https://doi.org/10.1016/j.scitotenv.2012.08.092

Kuppens, T., Van Dael, M., Vanreppelen, K., Thewys, T., Yperman, J., Carleer, R., Schreurs, S., Van Passel, S., 2015. Techno-economic assessment of fast pyrolysis for the valorization of short rotation coppice cultivated for phytoextraction. *J. Clean. Prod.*, **88**, 336-344. https://doi.org/10.1016/j.jclepro.2014.07.023

Li, Q., Zhang, Y., Hu, G., 2015. Techno-economic analysis of advanced biofuel production based on bio-oil gasification. *Bioresour. Technol.*, **191**, pp.88-96. https://doi.org/10.1016/j.biortech.2015.05.002

Lin, L., Shah, A., Keener, H., Li, Y., 2019. Techno-economic analyses of solid-state anaerobic digestion and composting of yard trimmings. *Waste Manage.*, **85**, 405-416. https://doi.org/10.1016/j.wasman.2018.12.037

Mehrdad, R., Seifmanesh, S., Chavoshi, F., Aminian, O., Izadi, N., 2014. Epidemiology of occupational accidents in Iran based on social security organization database. *Iran. Red. Crescent. Med. J.*, **16**(1). https://doi.org/10.5812/ircmj.10359

Mota, B., Gomes, M.I., Carvalho, A., Barbosa-Povoa, A.P., 2015. Towards supply chain sustainability: economic, environmental and social design and planning. *J. Clean. Prod.*, **105**, 14-27. https://doi.org/10.1016/j.jclepro.2014.07.052

Násner, A.M.L., Lora, E.E.S., Palacio, J.C.E., Rocha, M.H., Restrepo, J.C., Venturini, O.J., Ratner, A., 2017. Refuse Derived Fuel (RDF) production and gasification in a pilot plant integrated with an Otto cycle ICE through

Aspen plus™ modelling: Thermodynamic and economic viability. *Waste Manage.*, **69**, 187-201. https://doi.org/10.1016/j.wasman.2017.08.006

Nizami, A.S., Rehan, M., Waqas, M., Naqvi, M., Ouda, O.K., Shahzad, K., Miandad, R., Khan, M.Z., Syamsiro, M., Ismail, I.M., Pant, D., 2017. Waste biorefineries: enabling circular economies in developing countries. *Bioresour. Technol.*, **241**, 1101-1117. https://doi.org/10.1016/j.biortech.2017.05.097

Obi, F.O., Ugwuishiwu, B.O., Nwakaire, J.N., 2016. Agricultural waste concept, generation, utilization and management. *Niger. J. Technol.*, **35**(4), 957-964. http://dx.doi.org/10.4314/njt.v35i4.34.

Okine, A.R.A., 2007. Improving the preservation quality of high moisture by-product feedstuffs by ensilage and use of additives. Ph.D. Dissertation, Iwate University, Japan.

Pérez-López, P., Montazeri, M., Feijoo, G., Moreira, M.T., Eckelman, M.J., 2018. Integrating uncertainties to the combined environmental and economic assessment of algal biorefineries: A Monte Carlo approach. *Sci. Total Environ.*, **626**, 762-775. https://doi.org/10.1016/j.scitotenv.2017.12.339

Peters, J.I., 1959. Review of: Plant design and economics for chemical engineers: max s. Peters: McGraw-Hill Book Company, New York, 1958. 511 pp. $11.00. *Eng. Econ.*, **5**(1), 27-30. https://doi.org/10.1080/00137915908965075

Razmjoo, A., Qolipour, M., Shirmohammadi, R., Heibati, S.M., Faraji, I., 2017. Techno-economic evaluation of standalone hybrid solar-wind systems for small residential districts in the central desert of Iran. *Environ. Prog. Sustain. Energy*, **36**(4), 1194-1207. https://doi.org/10.1002/ep.12554

Sharara, M.A., Runge, T., Larson, R., Primm, J.G., 2018. Techno-economic optimization of community-based manure processing. *Agric. Syst.*, **161**, 117-123. https://doi.org/10.1016/j.agsy.2018.01.006

Silverman, R.E., Flores, R.J., Brouwer, J., 2020. Energy and economic assessment of distributed renewable gas and electricity generation in a small disadvantaged urban community. *App. Energy*, **280**, 115974. https://doi.org/10.1016/j.apenergy.2020.115974

Thaore, V., Chadwick, D., Shah, N., 2018. Sustainable production of chemical intermediates for nylon manufacture: a techno-economic analysis for renewable production of caprolactone. *Chem. Eng. Res. Des.*, **135**, 140-152. https://doi.org/10.1016/j.cherd.2018.05.026

Thiruvenkataswamy, P., Eljack, F.T., Roy, N., Mannan, M.S., El-Halwagi, M.M., 2016. Safety and techno-economic analysis of ethylene technologies. *J. Loss Prev. Process Ind.*, **39**, 74-84. https://doi.org/10.1016/j.jlp.2015.11.019.

Toop, T.A., Ward, S., Oldfield, T., Hull, M., Kirby, M.E., Theodorou, M.K., 2017. AgroCycle–developing a circular economy in agriculture. *Energy Procedia*, **123**, 76-80. https://doi.org/10.1016/j.egypro.2017.07.269.

Ullah, A., 2014. An integrated sustainability assessment of cotton cropping systems in Punjab, Pakistan: techno-economic performances, environmental impacts and eco-efficiency analysis (Doctoral dissertation, AIT).

Ullah, M., 2017. Techno-economic Assessment of Utilization of Food Processing Waste for Production of Energy and Chemicals. https://doi.org/10.7939/R3G44J321

Wagner, W.C., 1999. Sustainable agriculture: how to sustain a production system in a changing environment. *Int. J. Parasitol.*, **29**(1), 1-5. https://doi.org/10.1016/S0020-7519(98)00173-8.

Wang, B., Dong, F., Chen, M., Zhu, J., Tan, J., Fu, X., Wang, Y., Chen, S., 2016. Advances in recycling and utilization of agricultural wastes in China: Based on environmental risk, crucial pathways, influencing factors, policy mechanism. *Procedia Environ. Sci.*, **31**, 12-17. https://doi.org/10.1016/j.proenv.2016.02.002.

White, R., 2018. A techno-economic, sustainability and experimental assessment of the direct methanation of biodiesel waste glycerol (Doctoral dissertation, University of Leeds).

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