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Modeling Effective Functions on Technological Innovation System in Biomass Resources

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Abstract

The present research aims to model effective functions on technological innovation system in biomass resources (livestock waste) in rural areas in Tehran province with emphasis on use of technological innovation system. Considering the nature of investigation, it is a type of quantitative and practical study with correlational measures. a survey was used to collect the required data. The population consists of all cattle owners in Tehran province that according to the Agriculture Jihad organization, they are 4677 subjects in 11 cities. Of these, 355 owners were selected via the Cochran's formula through stratified random sampling method. The SPSS software was a means to analyze the data. The main result of the current study is that socio-cultural functions of innovation, transfer, distribution, promotion, and training of technological innovative knowledge and formation of technology markets are of effective factors on use of biomass resources and the impact of three functions on using biomass resources is meaningfully increasing. Moreover, the result of present research is development of a mathematical model for maximizing the effective functions on technological innovation system of biomass resources. This result can be helpful for investigators, related organizations, users (rural areas in Tehran) and others.

Keywords: Biomass resources, technological innovative system, mathematical modeling.

Introduction

Today's in the developing countries much attention is given to renewable energy sources. It seems that these types of energies can work efficiently for the developing countries since in the rural areas especially far reached regions transmission and distribution of the fossil fuels will be costly and expensive. Therefore, production of renewable energies locally can be a good alternative. I fact, the renewable energies are capable to facilitate the economic and social development process. In conditions the projects are designed intelligently and are planned on the basis of inputs and local cooperation[1].

The biomass energy is among the very first human energy sources. This type of energy is the only substitute for oil that is renewable and can be applied for hearting, producing electricity, cooking, fuel vehicles and providing process heat for industrial factories[2].

Biomass is a sort of energy is not affected by fluctuations in world oil prices. Using from liquid biofuels such as biodiesel and ethanol particularly in the developing countries reduces the economic burden of imports of petroleum products. As a matter of fact, biomass refers to a name derived from vegetable matter photosynthesis that the solar energy in this plant matter makes water and carbon dioxide into organic matter[3].

Currently, the portion of biomass in providing the required energy of the industrialized countries is less than 3%. Unlike fossil fuels that are in form of condensed layers , biomass is diluted and the cost of collecting large amounts of energy due to the economic use of the energy and being dispersed, having low energy density and often because of being wet is significant[4].

Accordingly, use of renewable and local energies like biogas resulted from one of the most frequency type of biomass resources, livestock waste, can be a good alternative for dealing with energy crisis and increase of demand in the rural areas of Tehran province.

Therefore, the present research aims to design a model for use of biomass resources (livestock waste) in the rural areas of Tehran province with focus on application of technological innovation system (TIS).

Review of Literature: The knowledge – based economic development process requires infrastructures for commercialization of the research findings and facilitation of transactions of technology and appropriate transitions of technology. One of mechanism has been recently taken into consideration for facilitating developmental activities of technologies, offer and demand strength, and transparency and strengthens the IT market in the world is technology markets. Indeed, this function makes a good communication between suppliers of technology and the buyers and creates an effective connection between backup infrastructures including organizations and institutions are associated to technology transactions in order to be able to make the process of technology transactions possible.

Theoretical Frame Work: In following definition of some technical terms are provided. Innovation: innovation consists all practical, technological, commercial and financial steps for successful development and application of biomass resources (livestock waste) in the rural areas[5].

Innovation system: in the present paper, innovation and development of technology are the results of a complex series of relations among active elements in a system called innovation system[6].

Technological innovative system (TIS): in the current research technological innovative system include a series of seven major functions (innovative policy making, establishment of facilitating and support infrastructures of technological innovation system , investigation, development and creation of knowledge , transmission, distribution and promotion of TI knowledge , development and improvement of innovative human resources, improvement of innovative entrepreneurship activities , and formation of technology markets) [7].

Biomass: biomass contains all substances found in the nature**.** Materials were alive in the immediate past, created from living beings or their waste. Biomass is discussed versus fossil fuels such as oil, gas and coal. The source of fossil fuels is like biomass, but the difference is that the fossil sources are made of biomass resources were alive in far past and are shaped under certain temperature and pressure conditions[8].

Biomass resources: In general biomass resources refer to all biodegradable components of products, waste water and agricultural waste (including vegetable and animal substances),forestry industries and other related industries, and biodegradable municipal and industrial waste[9].

Concepts and properties of the model: Physical/material models: they are the most tangible models. Generally working with a physical model due to its small size, inexpensive materials used in its preparation and/or its short time is simpler compared to what the model represents it[10]: i. logical/conceptual models: they refer to the things in the studied area. These things can be real or unreal[11], ii. mathematical models: the basis in mathematical modeling is to find a mathematical relation whose behavior is similar to the favorite system of modeling. The studied system can include a type of abstraction such as abstraction of physical or biological phenomena[12].

Research Background: Darestani Farahani (2007) in a research naming "study and modeling of Iran's innovation system in the field of nano technology" classified functions of national innovation system inn 6 groups of general policy making, capacity of knowledge creation, providing budget, facilitation of innovation and entrepreneurship, expansion of human resources, improvement of capacity of knowledge and technology transmission and distribution, and production of goods and services[13]. The engineering group of Keyhan Kavan Kousha in an article titling "national innovation system" considered appropriate access to financial resources as one of effective factors in reinforcement of entrepreneurship, and innovation in development of technology[14].

Bagheri moghadam et al in their study naming "action plan and roadmap for the development of fuel cell and hydrogen technology" suggested eight functions as the major TIS functions for development of this technology in Iran[15].

Husseini et al worked on " national technology markets in Iran, conceptual framework and operational necessities" and stated that technology markets are categorized in terms of different indexes . According to the main responsibility, technology markets are divided into three main groups of technology markets of IT, technology markets of transactions and transmission of technology and the integrated form[16].

Haghi et al conducted a research naming " proposed strategies of the counseling engineers of Saz –e Ab Shargh for improvement of national innovation system in Iran " categorized the chief functions of national innovation system on the basis of organization of economic cooperation and development that have become a basis for study of national innovation system in many countries into seven groups of innovation policy making, financial facilities, legal support, coordinators, development of human resources, production of goods and presenting services[17].

The organization of municipalities in the project "potential survey of biomass resources in Iran" regarded investment channels for renewable energies in the rural areas as governmental financial support, international investment, business banks, non-bank financial institutions, general stock, and investment in the private sector [18].

Fadaie in his book titling " entrepreneurship" sees the most important motives for entrepreneurship without including rate of their impact as material motives and formation of social, service, family and individual capital[19].

Nouralahi in an article naming "renewable energies, the way to the future development "stated the most important purposes of developmental policies and rules as expansion of renewable energies in Iran[20].

The research center of Agriculture Jihad in its studies " development of a comprehensive scientific and technology plan for agriculture sector" that is a sub services of the scientific plan of Iran introduce the most important indexes and subjects in the agriculture innovation system[21].

Shah Rokni in an article naming " characteristics of innovation " stated that taking risk, need for achievement, creativity and ideas on building confidence and self-belief, high perseverance, idealism, realism, being proactive, opportunity-oriented, results-oriented, work and action from being visionary and far-sighted are of common entrepreneurs' properties[22].

Huessieni in an paper titled "the role of promotion in acceptance of solar energy in the rural areas (carbon sequestration project) introduced the most important activities and methods for promoting of acceptance of solar energy among the rural communities[23].

Mousavi Abdolahi worked on production of biogas in the rural areas and presented the most important reasons for preference of biogas to other renewable energies[24].

Zartabi in an article titling "biogas production of clean energy from residues" believed that biogas as a eliciting factor for sustainable development for the rural and urban population in the developing countries can be positive[25].

Manono et al with regard to the results of the research in a paper "functions of the innovation systems of photovoltaic technology (a comparison between Japan and the Netherland) stated key functions and activities of the TIS as entrepreneurial activities, knowledge development, knowledge dissemination through networks (learning by interacting with each other), conducting research, market formation, resource mobilization, and advocacy coalitions[26].

Casto in a research naming "properties of entrepreneurship "asserted that responsibility, hard work, risk taking, creativity, flexibility, innovation, being independent, having high energy, learning from mistakes, determination, confidence, power, leadership, personality, pleasant and unpleasant, sharp intelligence and finesse, having the ability to anticipate needs, pursued ideas, guidance, optimism and accept criticism are of the most critical properties of an entrepreneur[27].

Musiolik worked on creation and formation of innovation systems: formal systems in the innovation system for local fuel accumulators in Germany and provided the functions of innovation system as well as concepts, and indexes for each function[28].

Jain in an investigation naming "knowledge about green energy and the role of promotion in India expressed that the basic needs for increasing knowledge about green energy and environmental sustainability exists.[29]

Methodology

The current research is a type of quantitative and practical investigation since it aims to develop practical knowledge in a specific field whose results are applicable for herders, farmers, experts, researchers, planners and policy makers in agricultural issues and optimizing fuel and energy consumption. Moreover, this research is a sort of descriptive –correlational one with survey.

Scope of Research: The time scope of research is in years 2011-2012. The subject scope is in field of designing a model for application of biomass resources (livestock waste) in the rural areas of Tehran province with emphasis on TIS. The geographical domain places in the rural areas of Tehran. The reason to select this scope is the potential of producing biogas resulted from livestock waste in the rural areas in all Iranian provinces with a capacity of 177659820 m^2 per day that the highest produced volume belongs to Tehran province with total capacity of 44092348 m^2 per day[18].

Validity and Reliability: To specify the instrument validity, content and face validity were used. That is, first the questionnaire was given to some experts then their comments were received. Also, in pre-test stage the content validity was measured.
In the current research also, the Cronbach's alpha was a means for assessment of the instrument. In a pilot study the questionnaire whose reliability was tested with the panel method was also tested in the similar region. Since the Cronbach's alpha for each index is larger than 0.70 , thus the reliability is accepted, which is an indication of internal correlation among the variables.

Sample Size and Sampling Method: To estimate the sample size, Cochran formula was used. The population size includes 4677 participants with t=1.96, level of confidence 95% and d=.05. The variance for studied variable is the dependent variable. Accordingly, 355 subjects were selected via proportionate stratified random sampling method.

$$n_{cochran} = \frac{\dfrac{P\,(1-p)\,z^2_{1-\alpha/2}}{d^2}}{1+1/N\left(\dfrac{P\,(1-p)\,z^2_{1-\alpha/2}}{d^2}-1\right)} = \frac{\dfrac{0.5*0.5*(1.96)^2}{(0.05)^2}}{1+1/4677\left(\dfrac{0.5*0.5*(1.96)^2}{(0.05)^2}-1\right)} = \frac{384.16}{1.0819} = 355.07$$

The Data Collection and Analysis: In the current paper, to achieve theoretical and field data, different methods like national and international studies, books, searching web sites and interviewing with experts of the new energies organization (SANA) and experts in Animal Deputy of Agricultural Jihad Organization of Tehran province. In addition to the methods were used for reviewing previous studies and experts' opinions, a question in form of a field study was applied in order to collect the required data from the rural areas.

The Conceptual Model: The present research is a type of practical study. Thus, the conceptual model is designed in terms of eight functions of TIS (the independent variables), and biomass resources in the rural areas in Tehran province (the dependent variable). Figure-1 shows the model.

Results and Discussion

Descriptive statistics: The descriptive findings refer to distribution of characteristics of the sample(s) in relation to a specific subject. This part consists of three sections: i. Evaluation of individual features of the respondents, ii. Evaluation of the respondents' viewpoint about related components to innovation functions, iii. Evaluation of the respondents; viewpoints related to the effective factors on the above components and prioritizing them.

It should be mentioned that due to bulk diagrams and charts, they were excluded in the current paper.

Identification and rating the manifest variables relevant to each factor (latent variables) through confirmatory factor analysis and structural equation modeling: In order to test the appropriateness of the question (manifest variables) for examining of the study factors (the latent variables) the confirmatory factor analysis (LISREL software) was used. In this stage, first the indexes of each confirmatory factor analysis models will be considered and in following probability of meaningful relationship between questions and studied factors via the LISREL diagrams in either forms of being meaningful and standard will be discussed.

The results of software computations for factor analysis indexes relevant to the functions of the model are presented in Table 1. The written codes in the table include functions of innovation policies (A), function of establishment of facilitation and supporting technological innovation (B), function of research, development and creation of innovation knowledge (C), socio-cultural function of innovation (D), function of transfer, promotion, distribution and training of the technological innovation (E), function of development and promotion of innovative human resources (F), function of promotion of technological entrepreneurship (G), and function of formation of technology markets (H).

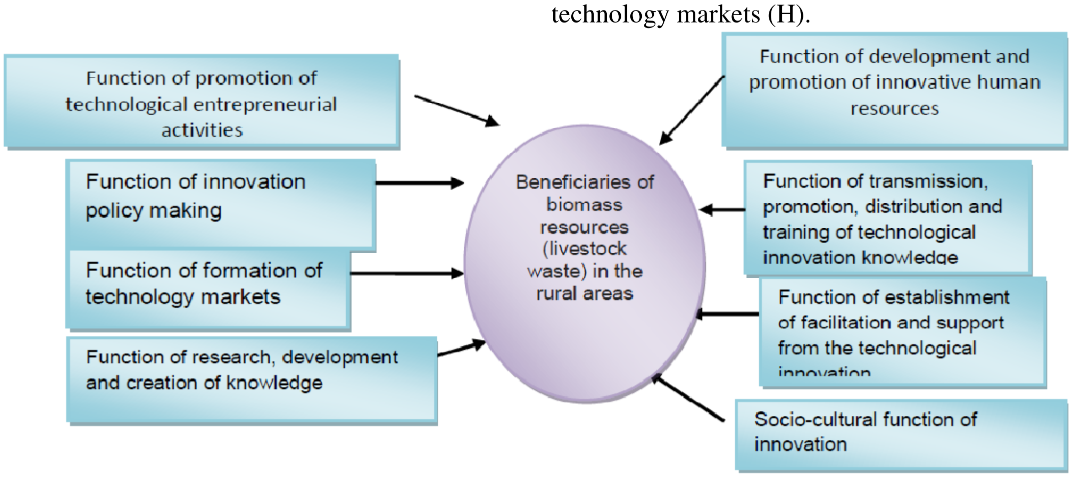

Figure-1
The conceptual model

Table-1
Indexes of factor analysis related to the function of policy making of innovation

	A	B	C	D	E	F	G	H
Chi-Square	111.17	137.67	15.18	5.00	25.24	7.18	126.02	13.26
Df	65	65	14	3	9	4	90	9
Chi-Square/ Df	1.71	2.11	1.08	1.66	2.80	1.79	1.740	1.47
RMSEA	.045	.067	.066	.011	.027	.065	.036	.030
GFI	.98	.97	.94	.98	.97	.93	.92	.95
AGFI	.94	.95	.93	.95	.96	.91	.90	.92
CFI	.91	.93	.94	.97	.96	.92	.91	.93
NFI	.90	.92	.91	.96	.96	.94	.91	.93
RMR	.011	.031	.029	.005	.018	.049	.043	.020

As it can be seen in the table above: Value of x2/df in all cases are smaller than 3 that is an indication of proper fit of the model. Root mean square error of approximation (RMSEA) in the presented model for all the model variables is less than 0.08. The value of GFI, AGFI, and NFI in the study model should be greater than 0.9. The value of RMR is in all variables is smaller than 0.05.

The computation diagram by use of the LISREL software related to the function of innovation policy making (A) is represented in the figure-2. To prevent from many figures in this section the rest of tables are not provided here. According to the indexes and outputs of the LISREL outputs it can be said that the selected variables for measurement of the model functions have no required validity.

The Pearson's correlation coefficients: In order to determine the coefficients of technological innovation system with related components of the biomass resources, the Pearson's correlation coefficient was used. Table 2 shows the results.

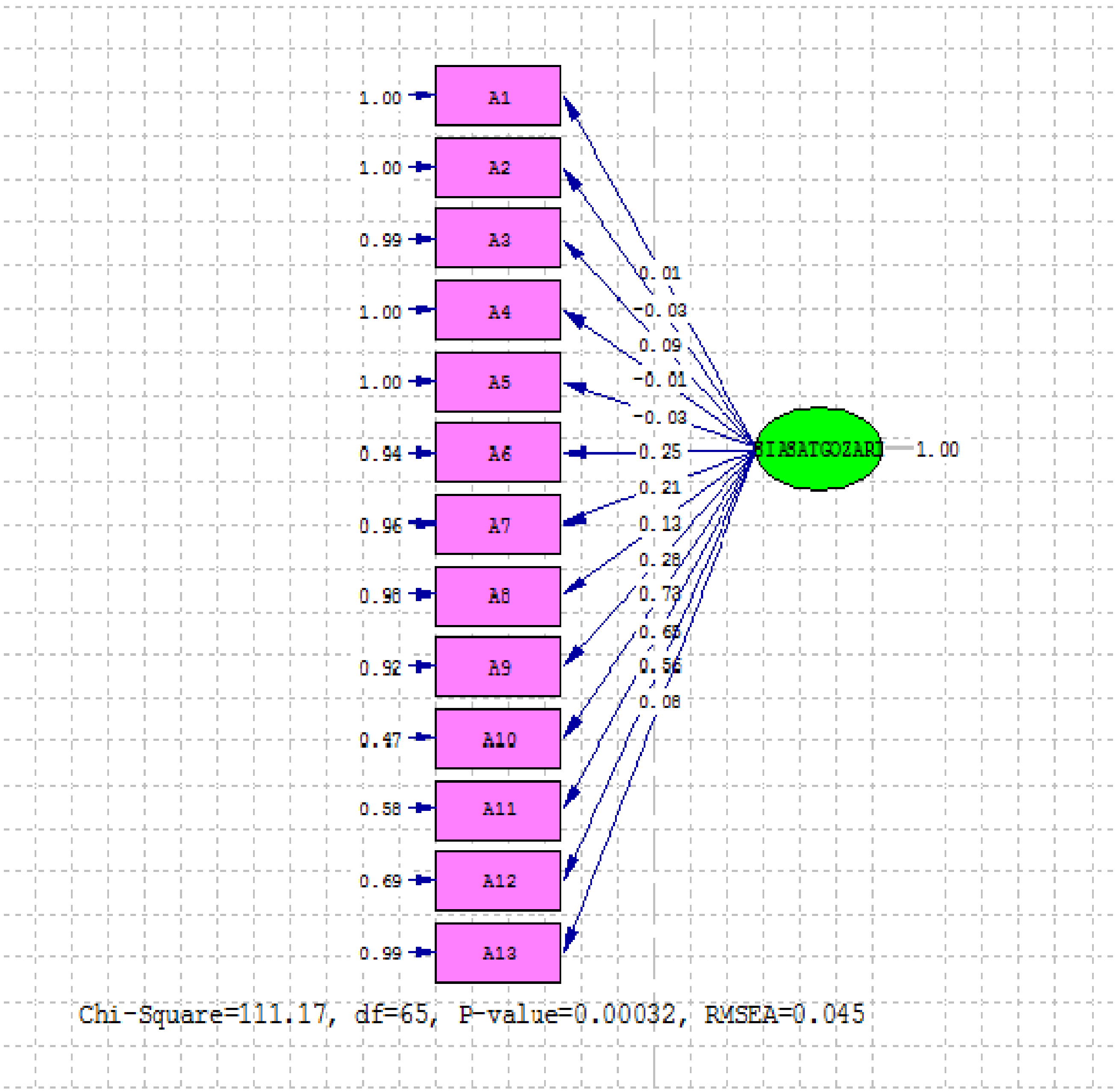

Figure-2
The estimated model for function of policy making of innovation

Table-2
Function of dimensions of TIS on usage of biomass resources

Technological innovation model	Correlation coefficient	result
Innovation policy	0.092	No meaningful relation
Infrastructure to facilitate and support the technological innovation	-0.041	No meaningful relation
Research, development and creation of knowledge	-0.033	No meaningful relation
Social – cultural of innovation	0.130*	Hypothesis confirmed and a direct and meaningful relation
Transmission, distribution, promotion and training of technological innovation	0.120*	Hypothesis confirmed and a direct and meaningful relation
Development and promotion of innovative human resource	0.055	No meaningful relation
Promotion of technological entrepreneurship activities	0.079	No meaningful relation
Formation of technology markets	0.180**	Hypothesis confirmed and a direct and meaningful relation

** Sig= 0.01(Two-tailed test) * Sig= 0.05 (Two-tailed test)

According to the computations, the socio-cultural function of innovation, transfer, promotion, distribution and training of technological innovation knowledge and formation of technology markets hold a direct and meaningful association with the biomass resources. The related regression model is provided in following.

The mathematical model of the effective components on technological innovation system (biomass resources): In order to the maximum mathematical model, the normalized impact factors were required. In following, the normalized impact factors of the functions have a meaningful relation to the biomass resources are provided in table 3.

Table-3
The normalized coefficients of functions of TIS on usage of biomass resources

Independent variables	Regression coefficient	Impact fact
Social – cultural of innovation	0.130	0.30
Transmission, distribution, promotion and training of technological innovation	0.120	0.28
Formation of technology markets	0.180	0.42
total	0.430	1

To create the mathematical model for on the basis of computed impact factors, the goal function will be equal to: Max $\theta = 0.30\ x_1 + 0.28\ x_2 + 0.42\ x_3$

Where, x1 through x3 represents socio-cultural function of innovation, transfer, promotion, distribution and training of technological knowledge function and function of technological markets and their impact factors are extracted from the table 3 respectively.

To determine limitations and values on the right hand side, the value 100 was determined as the maximum value and in terms of significance of each of Meaningful functions of the TIS values of 3.4, 7.2, and 24.4 were assigned to respectively.

The specified number is the maximum value of the score of each function on the right hand. The coefficients of each limit was entered the model via the computed factor load. Therefore, the socio-cultural constraint of innovation, transfer, promotion, distribution and training of technological innovation knowledge constraint and limitation of technology markets will be equal to:

$0.81\ x_{11} + 0.54\ x1_2 + 0.37\ x_{13} + 0.18\ x_{14} \leq 24.4$

$0.75\ x_{21} + 0.70\ x_{22} + 0.58\ x2_3 + 0.42\ x_{24} + 0.29\ x_{25} + 0.28\ x_{26} + 0.28\ x_{27} + 0.11\ x_{28} + 0.07\ x_{29} + 0.06\ x2_{10} + 0.04\ x_{211} + 0.01\ x2_{12} \leq 7.2$

$0.70\ x3_1 + 0.69\ x3_2 + 0.60\ x3_3 + 0.57\ x_{34} + 0.28\ x_{35} + 0.28\ x_{36} \leq 3.4$

Where, the parameters of the first constraint are equal to the parameters of the manifest variables column in the rating table and the significance of effective variables in the socio-cultural function of innovation, the parameters of the second constraint is equal to variables in the manifest column of the rating table and significance of the effective variables in the function of transfer, distribution, promotion and training of technological innovation and the third constraints equal the manifest variables column of the rating table and significance of the effective variables in the formation of technology markets function.

Finally, the non-zero condition of all variables must be considered in order to have no neutral variable.

$x \geq 0, \forall i$

Now, according to determination of the goal function, limitations and conditions of the problem, the linear programming will be determined as below :

$$\text{Max } \theta$$
$$\Sigma\, w_i\, x_{ij} \leq b \ (i = 1 \ldots n)$$
$$x \geq 0 \ \forall i$$

Where, θ = the final score of the model, W= parameters or factors of impact, x= problem variables, b= hand right values or the maximum score of the model.

Table-4
Rating and significance of the effective variables on socio-cultural function of innovation

Latent variable	Manifest variables	Reference load factor
Socio-cultural function of innovation	Supporting the business groups especially development of the private sector in field of technology and biogas	0.81
	Short-time support of biogas consumption due to improvement of its consumption pattern	0.54
	Creation of a competitive environment in relation to this technology	0.37
	Introduction of advantages of biogas technology	0.18

Discussion: To mention some important results of the present research, it can be said that three socio-cultural function of innovation, transfer, promotion, distribution and training of the technological innovation knowledge and formation of technology markets were counted as the effective factors on use of the biomass resources and the impact of three functions on use of the biomass resources is meaningfully increasing.

The results of this research about the impact of socio-cultural function of the innovation, and functions of transfer, promotion, distribution and training of technological innovation Knowledge and formation of technology markets were to some extent in accordance to Yucel's results.[30] Any change in transfer, promotion, distribution, and training of knowledge and in following the resulted socio-cultural changes raised by innovation can speed up the process of use of biomass resources (livestock waste) in production of biogas. This result is therefore, in line with Jain results.[29] In regard to the significance of technology markets, the results were obtained by Research Center of Urban and Rural Management can be mentioned.[18]

The researcher in the preset study states that establishment of a research and development system through making a close and continuous relation with the research and development unit with customers, unit of market studies, entrepreneurs and other units are of the points that cause growth of business in the entrepreneurship organizations.

The most salient result for the current research is development of the mathematical model for maximizing the effective functions on the TIS of biomass resources. This result can be influential for researches, organizations and users (rural areas in Tehran) and others.

Table-5
Rating and significance of the effective variables on function of transmission, promotion, distribution and training of technological innovation knowledge

Latent variable	Manifest variables	Reference load factor
Function of Transmission, promotion, distribution and training of technological innovation knowledge	Printing and distribution of promotional literature - training (such as magazines, news bulletins)	0.75
	Classes and workshops in the field of biogas technology	0.70
	Advocates public meeting with the villagers	0.58
	Transfer of relevant Technology	0.42
	Informal transfer to and by companies that are active in this field	0.29
	Biogas technology-related facilities	0.28
	Appointment with any of the villagers in their homes and farms	0.28
	Visit villagers from exemplary biogas unit	0.11
	Virtual exhibitions through an integrated information network on the Internet	*0.07*
	Villagers continuing education to enhance their skills and experience in the field of biogas technology	*0.06*
	Villagers continuing education to enhance their knowledge in the field of biogas technology	*0.04*
	The use of mass media such as radio and television	*0.01*

Table-6
Rating and significance of the effective variables on function of technology markets formation

Latent variable	Manifest variable	Reference load factor
Formation of technology markets	Financial services	0.70
	Creation of centers providing information and statistics in the field of biogas technology	0.69
	Biogas technology assessment services	0.60
	Through the introduction of technology directly between buyer and seller	0.57
	Technical services	0.28
	Franchise service	0.28

Conclusion

The applied coefficients for the parameters of each limitation indicate the rating of every function elements. Thus, in order to maximize the TIS on usage of the biomass resources the following recommendations are provided: i. allocation of some technical funding for development of the model by use of coefficients of each component of the function, ii. allocation of the human force (hour/person) for the future researches.

Allocation of organizational resources in terms of computational coefficients of the functions: i. Doing developed modeling on the basis of evaluation of the functions performance in the rural regions of Tehran for comparing the improvement projects and computation of their efficiency for optimizing operational projects, ii. expansion of the future studies in terms of the meaningful relationship of the research model and adding exploratory functions and redoing of the current article calculations for improvement of the mathematical model

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