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MATHEMATICAL AND STATISTICAL ANALYSIS OF FARM LEVEL AGRICULTURAL SECTOR IN BANGLADESH UNDER UNCERTAINTY

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ABSTRACT: *This study presents three different mathematical models for profit optimization of agricultural products in Bangladesh. To develop a Mixed Integer Linear Programming (MILP) model and analyze this model for two situation of demand uncertainty. Considering demand will be known before production and demand will be known after production. For the mentions of two cases, we investigate the change of solution applying least demand, maximum perhaps demand and extreme demand scenarios. I think this is real life problem and this analysis will be helpful for all types of agricultural producers. The proposed MILP model is to maximize the total profit and also to estimate the profitable production locations. The formulated MILP model were solved by A Mathematical Programming Language (AMPL) and results obtained by appropriate solver MINOS. Numerical example with the sensitivity of several parameters has been deployed to validate the models. Results show that maximum perhaps demand scenario gets better solution according to our expected value compare of other two scenarios.*

KEYWORDS: Optimization, Mixed integer linear program, Demand, Uncertainty, Agricultural products

INTRODUCTION

People's Republic of Bangladesh is a densely populated developing country in the Southern Asia and its area is 147,872 km2. In 2017 its populations become more than 160 millions. The population density of Bangladesh is about 1,082/km2, which is that the highest within the Southern Asian countries. Hence the large population became burden due to the limited resources of the country. Although Bangladesh is on track for Middle Income Country status by 2021, agriculture remains the most important employer within the country by far; and 47.5% of the population is directly employed in agriculture and around 70% depends on agriculture in one form or another for his or her livelihood. Although, most of the sectors of Bangladesh develops day by day but GDP of agricultural sector has decreased. During

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the fiscal year 2012-13 to 2016-17, the broad agriculture sector contributed 17.10%, 16.3%, 16.1%, 15.5% and 14.8 respectively to the total GDP (BBS). Nearly three fifth of the agricultural GDP comes from the crop sub-sector; the opposite contributors so as of magnitude are fishery, livestock and forestry. Bangladesh is additionally one among the foremost vulnerable countries to weather variability and natural disasters (World Bank, WB, 2007). The present government has targeted to scale back poverty rate to 25% and 15% by 2013 and 2021 respectively. Various microfinance programmes also help the poor to scale back the food insecurity and poverty of the country.

In this research, Farmer production location problem is formulated as a MILP model which maximizes the profit of return on investment, and at the same time optimizes location, cost price and the investment. MILP model is also derived to determine the sites for manufacturer and the best allocation for both the farmer and manufacturer. Serious arable land shortage and food security crisis could arise under disadvantageous rapid urbanization and industrialization, leading to complexities in identifying desired optimum plans for agriculture production (Long et al. 2009. Haouari and Azaiez (2001) analyzed linear and nonlinear optimization models. Montazar and Rahimikob 2008; Kaur et al. 2010); deterministic linear programming and chance-constrained linear programming models to the goal program approach Vivekanadan et al. (2009), Using the suitable transformation of Charnes and Cooper (1962), the formulated MILFP is solved by AMPL. Among these, Charnes and Cooper (1962) described a transformation technique which transforms the MILFP into equivalent linear program. This method is sort of simple but got to solve two transformed model to get the optimal solution. Khairul et al. (2018) analyze the farmer profit optimization by using MILP model.

Single grain production structure, which has not logically integrated various agricultural activities during a supplementary and/or complementary fashion, may have difficulties in improving the economic conditions of grain farmers Long et al. (2009). The multi-objectives of accelerating food production, enhancing farmers' income and also maintaining ecological stability are met in farming Othniel and Gopal (2008); Krishna et al. (2008); Dillon et al. (2010). Subsequently, the best potential opportunities for increasing agricultural productivity and improving the socioeconomic status of the agricultural dwellers exist through agricultural production structure optimization Ehui and Jabbar (1993; Agbonlahor et al. (2003).

Bidhandi et al. [2], analyzed two-stage random program, which incorporates as uncertainty parameters the operational prices, the client demand and therefore the capability of the facilities. Configuration choices square measure thought-about as initial stage variables and choices connected with transporting product from suppliers to customers square measure thought-about as second stage variables. Nickel et al. [3], narrated a multi-stage random MILP model which including the money choices, to see the placement of the facilities, the flows of product and different investments. Azaron et al. and Baghalian et al. [4-5],

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developed a random mathematical formulation to deal the problem of SCN style behind demand and provide unsure, that were sculpturesque through distribution functions. Cardoso et al. [6], conferred a mixed-integer applied mathematics formulation for SCN under demand uncertainty and optimize cost minimization.

Therefore, in response to the above challenges, a mixed integer linear programming (MILP) is developed in this paper. The developed MILP model will incorporate within a general framework for better accounting for complicated interactions, demand uncertainties before and after production for three scenarios least demand, maximum perhaps demand and extreme demand in agricultural production structure optimization. Then, the developed MILP model is applied to a case study of Bangladesh as a typical traditional agricultural region, in Dinajpur, Mymensingh and Manikgonj district. The purpose of this paper is to optimize agricultural production structure of major grain producing locations, such that local food security could be guaranteed, grain farmers' welfare, food varieties could be increased, extra remuneration could be provided and farm labor could be fuller utilized.

The reminder of this paper is organized as, Data collection; Model formulation which describes the concept of MILP problem, Solution and result analysis. Finally, the conclusions and contributions of this study are discussed.

Data collections:
Data collecting may be a crucial step, since the actual information influences the results of the study. If the results accuracy defines the problem under study, those results enable deeper information of the problem. Typically this stage consumes a long time, and contributes to correct information and to supply input to the mathematical model. We tend to developed our MILP model by collecting actual information for agricultural product optimization in at random elite samples of 240 market players who are directly or indirectly involved in agricultural business from three districts of Bangladesh.

Mathematical Formulation of MILP Models:
Before mathematical formulation of MILP model, we have discussed basic notations, parameters and decision variables that are relevant with our work in this study.

Sets	
L	Set of production locations indexed by l
C	Set of customers indexed by j
P	Set of products indexed by i

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Parameters	
l_{il}	Labor Requirement of i^{th} product at l^{th} location (ha)
h_{il}	Labor(hours) need for i^{th} product at l^{th} location
w_{il}	The amount of others resources need of i^{th} product at l^{th} location (ha)
p_{1lt}	Total of hours used for all products
f_{il}	Fertilizer requirement of i^{th} product at l^{th} location (kg/ha)
R_{il}	Produced rate per unit of time
t_{ilt}	Unit transportation cost for i^{th} product at l^{th} location of t^{th} time (TK/unit)
r_{il}	The amounts of raw materials need to produce i^{th} product at l^{th} location
p_{il}	The production cost of i^{th} product to l^{th} location at ($/unit).
H_{il}	Unit holding cost of i^{th} product for l^{th} location
$g^{*}{}_{il}$	Fertilizer cost of i^{th} product at l^{th} location (TK/unit).
p_s	Uncertainty probability of
ud_{il}	Unit demand of i^{th} product for l^{th} location
y_1	Per unit land cost
y_2	Per unit raw material cost
y_3	Per unit labor cost
y_4	Per unit fertilizer cost
y_5	Per unit cost of others resources
β	Any large positive constant

Decision variables:	
x_{ilt}	Total amount of i^{th} product produced from l^{th} location for t^{th} time
s_{lij}	Total amount of i^{th} product sells from l^{th} location for t^{th} time
X_{1il}	Total available land of i^{th} product at l^{th} location
X_{2il}	Total available raw materials of i^{th} product at l^{th} location
X_{3il}	Total available labor hours of i^{th} product at l^{th} location
X_{4il}	Total available fertilizer of i^{th} product at l^{th} location
X_{5il}	Total amount of others resources available of i^{th} product at l^{th} location
Z_1	Total income
Z_2	Total cost
π_1	The maximum profit
$ZZ_l = \begin{cases} 1, if\ location\ l\ is\ used, \\ 0, else \end{cases}$	

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Farmers Model:
Objective function and constraints,

$Maximize, \pi_1 = z_1 - z_2$ Where, $z_1 = \sum_{l=1}^{L}\sum_{i=1}^{P}\sum_{t=1}^{T} y_{ilt} s_{ilt}$ $z_2 = \sum_{i=1}^{P}\sum_{l=1}^{L} zz_l u_{il} + \sum_{l=1}^{L}\sum_{i=1}^{P}\sum_{t=1}^{T}((t_{ilt} + p_{il}) x_{ilt} + H_{il} z_{ilt} + X_{1IL} y_1 + X_{2il} y_2 +$ $X_{3il} y_3 + X_{4il} y_4 + X_{5il} y_5)$	(1)
$\sum_{t=1}^{T} x_{ilt} v_{il} \le X_{1il}, \forall t$	(1.1)
$\sum_{t=1}^{T} x_{ilt} l_{il} \le X_{2il}, \forall t$	(1.2)
$\sum_{t=1}^{T} x_{ilt} r_{il} \le X_{3il}, \forall t$	(1.3)
$\sum_{t=1}^{T} x_{ilt} f_{il} \le X_{4il}, \forall t$	(1.4)
$\sum_{t=1}^{T} x_{ilt} w_{il} \le X_{5il}, \forall t$	(1.5)
$\sum_{t=1}^{T} x_{ilt} \le ud_{il}, \forall i, l$	(1.6)
$\sum_{t=1}^{T} y_{ilt} \le ca_{il}, \forall i, l$	(1.7)
$\sum_{i=1}^{P}\sum_{t=1}^{T} y_{ilt} \le \beta * zz_l, \forall l$	(1.8)
$y_{ilt} - x_{ilt} \le 0$	(1.9)
$\sum_{l=1}^{L}\sum_{t=1}^{T} 1/R_{il} * x_{ilt} \le p_{1lt}, \forall i$	(1.10)
$\sum_{i=1}^{P}\sum_{l=1}^{L} z_{il0} = IS_{il}, \forall t$	(1.11)
$x_{ilt} + z_{il(t-1)} = y_{ilt} + z_{ilt}$	(1.12)

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$\boldsymbol{x_{lit}, y_{lit}, f_{li}, w_{li}, l_{li}, h_{li}, p_{li}, IS_{il}, r_{li}, v_{li}, p_{1li}, ca_{li}, R_{li}, X_{1il}, X_{2il}, X_{3il}, X_{4il}, X_{5il}, ud_{li}}$, $\boldsymbol{\beta, H_{li}, u_{li}}$, **are non-negative and** $\boldsymbol{zz_l}$ **is binary.**	(1.13)

Equation (1) is the objective function, which maximize the total profit. Here the objective function is the difference between total return and total investment. Constraints (1.1-1.5) show that the total available resources for land, raw materials, labor, fertilizer and others which produced all kind of products at all locations. Constraints (1.6) defines that the total amount of products is less than or equal to the total demand for all locations. Constraints (1.7) represents that the total amount of sell products is less than or equal to the total capacity for all locations. Constraints (1.8) assurance that a location is used when and only if any product is need. Constraints (1.9) assurance that the total amount of product produced from all location for all customers is greater than or equal to the total amount of product sells for all customer. Constraints (1.10) described that the total of hours used by all products may not exceed hours available, in each week. Constraints (1.11) present that the total amount of initial inventory and the given value must equal. Constraints (1.12) ensure that the total amount produced and taken from inventory must equal to the sold and put into inventory. Equation (1.13) is the nonnegative constraints.

Farmer Model under uncertainty:
Agricultural sector plays a dominant role in the growth and stability of the economy of Bangladesh. But, Bangladesh suffers different types of natural calamities such as floods, river bank erosion, cyclones, drought etc. Especially, the effects of floods and cyclones large-scale of agricultural products damages most of the year in Bangladesh. In the model formulation several uncertainties such as natural calamities, hartal and demand have been considered. When we know the specific demand scenario for any kind of product then it is easy to make decision, on the other hand we cannot make decision before we know the demand. Implementation any decision we should have real information about the market demand of that product. When we know the demand, it is very easy to determine the sales quantities as well as to calculate our return from that product and we establish production schedules. But, if we don't know the demand then it is called demand uncertainty. Here we consider three situations for demand uncertainty.

First situation: If demand will be known before any decision
If demand is known after production, in this case demand uncertainty is analyzed after any kind of decisions making. In this situation, several uncertainties (demand, cost, production etc.) consider for the model formulation. Let us consider three sets of variables, which are known as demand scenario. Here we assume ud_{ijs} is the demand with three scenarios least demand, maximum perhaps demand and extreme demand where p_s denotes the uncertainty probability, we have
Objective function and constraints,

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$Maximize, \pi_2 = z_3 - z_4$ Where, $z_3 = \sum_{l=1}^{L}\sum_{i=1}^{P}\sum_{t=1}^{T} y_{ilts} s_{ilts} p_s$ $z_4 = \sum_{i=1}^{P}\sum_{l=1}^{L} zz_{ls} u_{ils} + \sum_{l=1}^{L}\sum_{i=1}^{P}\sum_{t=1}^{T}((t_{ilts} + p_{ils}) x_{ilts} + H_{ils} z_{ilts} + X_{1ILs} y_{1s} +$ $X_{2ils} y_{2s} + X_{3ils} y_{3s} + X_{4ils} y_{4s} + X_{5ils} y_{5s}) * p_s$	(2)
$\sum_{t=1}^{T} x_{ilts} v_{ils} \leq X_{1ils}, \forall t$	(2.1)
$\sum_{t=1}^{T} x_{ilts} l_{ils} \leq X_{2ils}, \forall t$	(2.2)
$\sum_{t=1}^{T} x_{ilts} r_{ils} \leq X_{3ils}, \forall t$	(2.3)
$\sum_{t=1}^{T} x_{ilts} f_{ils} \leq X_{4ils}, \forall t$	(2.4)
$\sum_{t=1}^{T} x_{ilts} w_{ils} \leq X_{5ils}, \forall t$	(2.5)
$\sum_{t=1}^{T} x_{ilts} \leq ud_{ils}, \forall i, l$	(2.6)
$\sum_{t=1}^{T} y_{ilts} \leq ca_{ils}, \forall i, l$	(2.7)
$\sum_{i=1}^{P}\sum_{t=1}^{T} y_{ilts} \leq \beta * zz_{ls}, \forall l$	(2.8)
$y_{ilts} - x_{ilts} \leq 0$	(2.9)
$\sum_{l=1}^{L}\sum_{t=1}^{T} 1/R_{ils} * x_{ilts} \leq p_{1lts}, \forall i$	(2.10)
$\sum_{i=1}^{P}\sum_{l=1}^{L} z_{il0s} = IS_{ils}, \forall t$	(2.11)
$x_{ilts} + z_{il(t-1)s} = y_{ilts} + z_{ilts}$	(2.12)
$\boldsymbol{x_{lits}, y_{lits}, f_{lis}, w_{lis}, l_{lis}, h_{lis}, p_{lis}, IS_{ils}, r_{lis}, v_{lis}, p_{1lis}, ca_{lis}, R_{lis}, X_{1ils}, X_{2ils}, X_{3ils}, X_{4ils}, X_{5ils}, ud_{lis}, \beta, H_{lis}, u_{lis}}$, **are non-negative and** $\boldsymbol{zz_{ls}}$ **is binary, where s is the scenario.**	(2.13)

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From equation (2), we determine the objective value. The objective value is the difference between total return and total investment. In this case, the objective value for the demand uncertainty that is we do not know the demand before production. Actually, these kinds of uncertainty not only demand uncertainty but also various uncertainties like cost, production, sells etc.

Situation two: If demand is known after production

If demand is known after production, in this case demand uncertainty is effected only the demand on sold products. For model formulation, we consider three sets of variables, which are known as demand scenario. Here we assume ud_{ijs} is the demand with three scenarios, we get

Objective function and constraints,

$Maximize, \pi_3 = z_5 - z_6$ Where, $z_5 = \sum_{l=1}^{L}\sum_{i=1}^{P}\sum_{t=1}^{T} y_{ilts} s_{ilts} p_s$ $z_6 = \sum_{i=1}^{P}\sum_{l=1}^{L} zz_l u_{il} + \sum_{l=1}^{L}\sum_{i=1}^{P}\sum_{t=1}^{T}((t_{ilt} + p_{il}) x_{ilt} + H_{il} z_{ilt} + X_{1IL} y_1 +$ $X_{2il} y_2 + X_{3il} y_3 + X_{4il} y_4 + X_{5il} y_5)$	(3)
$\sum_{t=1}^{T} x_{ilt} v_{il} \le X_{1il}, \forall t$	(3.1)
$\sum_{t=1}^{T} x_{ilt} l_{il} \le X_{2il}, \forall t$	(3.2)
$\sum_{t=1}^{T} x_{ilt} r_{il} \le X_{3il}, \forall t$	(3.3)
$\sum_{t=1}^{T} x_{ilt} f_{il} \le X_{4il}, \forall t$	(3.4)
$\sum_{t=1}^{T} x_{ilt} w_{il} \le X_{5il}, \forall t$	(3.5)
$\sum_{t=1}^{T} x_{ilts} \le ud_{ils}, \forall i, l$	(3.6)
$\sum_{t=1}^{T} y_{ilts} \le ca_{il}, \forall i, l$	(3.7)
$\sum_{i=1}^{P}\sum_{t=1}^{T} y_{ilts} \le \beta * zz_l, \forall l$	(3.8)

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$y_{ilts} - x_{ilt} \le 0$	(3.9)
$\sum_{l=1}^{L}\sum_{t=1}^{T} 1/R_{il} * x_{ilt} \le p_{1lt}, \forall i$	(3.10)
$\sum_{i=1}^{P}\sum_{l=1}^{L} z_{il0} = IS_{il}, \forall t$	(3.11)
$x_{ilt} + z_{il(t-1)} = y_{ilts} + z_{ilt}$	(3.12)
$\boldsymbol{x_{lit}, y_{lits}, f_{li}, w_{li}, l_{li}, h_{li}, p_{li}, IS_{il}, r_{li}, v_{li}, p_{1li}, ca_{li}, R_{li}, X_{1il}, X_{2il}, X_{3il}, X_{4il}, X_{5il}, ud_{lis}, \beta, H_{li}, u_{li}}$, **are non-negative and** $\boldsymbol{zz_l}$ **is binary, where s is the scenario.**	(3.13)

From equation (3), we determine the objective value. The objective value is the difference between total return and total investment. In this case, the objective value for the demand uncertainty that is we know the demand before production. Actually, this kind of uncertainty is called demand uncertainty.

Solution approaches and result discussion

In order to solve the formulated MILP model we apply the well-known branch and bound Algorithm that is the process of spawning sub problems ignoring partial solution that cannot be better than the current best solution. Finally, it will be carried out by applying A Mathematical Programming Language (AMPL). MINOS optimization solver will be applied to optimize the problem and find the optimal solution. This program has accomplished on a Core-I3 machine with a 3.60 GHz processor and 4.0 GB RAM.

For the purpose of sensitivity analysis of our mentioned MILP model, we supposed a numerical example. Let us assume a firm has 3 locations, 5 types product Boro rice, Wheat, Green pepper, Cucumber, Carrot and with 4 cycle of time. Consider the unit production demand and production capacity of each locations are (5000, 4000, 4000, 3000, 3500), (6000, 5000, 3000, 4000, 3000), (6000, 5000, 4000, 3500, 3000) and (5500, 4300, 5000, 3500, 3800), (5000, 4000, 4500, 3800, 4000), (6000, 4500, 4000, 3500, 4200). Also, the trade of each production limit, transportation cost and unit selling price per cycle of time in each locations are {(4500, 4000, 4000, 3000), (3500, 5000, 4000, 4000), (5500, 4500, 3500, 3500)}; {(4000, 2500, 3500, 4200), (5000, 3000, 3000, 4500), (4500, 2500, 3000, 4000)}; {(5000, 3500, 4500, 3000), (4500, 3800, 4200, 3500), (4000, 3300, 4300, 3200)}; {(3000, 3500, 3500, 4000), (4000, 4500, 3000, 5000), (4000, 2500, 4500, 3500)}; {(6000, 3000, 4000, 3500), (5000, 4000, 3000, 4500), (5000, 4000, 3500, 4000)}; {(0.2, 0.1, 0.2, 0.1), (0.1, 0.2, 0.2, 0.2), (0.2, 0.2, 0.3, 0.1)}; {(0.2, 0.3, 0.2, 0.1), (0.1, 0.1, 0.2, 0.1), (0.1, 0.2, 0.3, 0.2)}; {(0.3, 0.2, 0.1, 0.2), (0.2, 0.1, 0.2, 0.2), (0.1, 0.2, 0.2, 0.1)}; {(0.4, 0.3, 0.2, 0.1), (0.2, 0.2, 0.3, 0.1), (0.3, 0.3, 0.1, 0.2)}; {(0.2, 0.3, 0.2, 0.3), (0.2, 0.2, 0.1, 0.2), (0.1, 0.3, 0.2, 0.2)} and {(23, 24, 25, 24), (22, 25, 22, 25), (21, 23, 24, 24)}; {(27, 29, 28, 29), (26, 28, 29, 27), (27, 26, 28, 27)}; {(30, 31, 32, 31), (31, 30, 33, 32), (30, 32,

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32, 30)}; {(17,17, 19, 20), (17, 18, 18, 19), (20, 21, 19, 21)}; {(19, 18, 20, 21), (22, 20, 21, 22), (22, 21, 20, 19)} respectively

Produce each type of products requires land, raw materials, labor, fertilizer and others resources. The data for the following farm is given below:

Various resource for production	Per unit production requirements					
	Unit cost	Boro rice	Wheat	Green peeper	Cucumber	Carrot
Land	2.5	(0.8, 0.9, 1.0)	(1.4, 1.2, 1.3)	(1.5, 1.4, 1.3)	(1.2, 1.0, 1.1)	(1.3, 1.2, 1.4)
Raw materials	3	(1.5, 1.3, 1.4)	(1.1, 1.0, 1.2)	(1.2, 1.2, 1.1)	(1.0, 0.8, 0.9)	(0.5, 0.6, 0.5)
Labor	4	(2.0, 2.1 2.2)	(1.2, 1.1, 1.3)	(1.8, 1.5, 1.7)	(0.7, 0.6, 0.7)	(0.8, 0.7, 0.8)
Fertilizer	2	(2.5, 2.6, 2.4)	(1.0, 1.1, 1.0)	(1.3, 1.2, 1.2)	(0.5, 0.4, 0.4)	(0.6, 0.5, 0.6)
Others	2.5	(1.5, 1.4, 1.3)	(0.8, 0.8, 0.9)	(1.4, 1.2, 1.3)	(1.3, 1.4, 1.5)	(1.1, 1.0, 1.2)
Demand		17000	14000	11000	10500	9500

Table 1. Production demand and various resources information

Another announcement concerning our parameters for the formulation of MILP model are described in the following table:

Parameters	P1	P2	P3	P4	P5
Rate of produce per cycle(tons)	(170, 120,150)	(110, 100,120)	(120, 110,100)	(110, 100,120)	(100, 120, 100)
Initial stock	(10, 20, 15)	(20, 00, 20)	(15, 30, 25)	(00, 40, 50)	(18, 20, 10)
Unit production cost	(1.5, 1.2, 1.3)	(2.0, 1.8, 1.5)	(2.5, 1.2, 1.8)	(1.2, 1.5, 1.2)	(1.0, 1.2, 1.3)
Unit holding cost	(2.1, 1.5, 2.2)	(2.3, 1.8, 1.8)	(2.2, 2.1, 2.0)	(2.1, 1.9, 2.2)	(2.2, 1.5, 1.6)

Table 2. Information about various parameters

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Agricultural products prices are very unstable all over the world markets, especially in Bangladesh market. The following figure1, Shows the weekly average market price for different products in a certain period of Bangladesh.

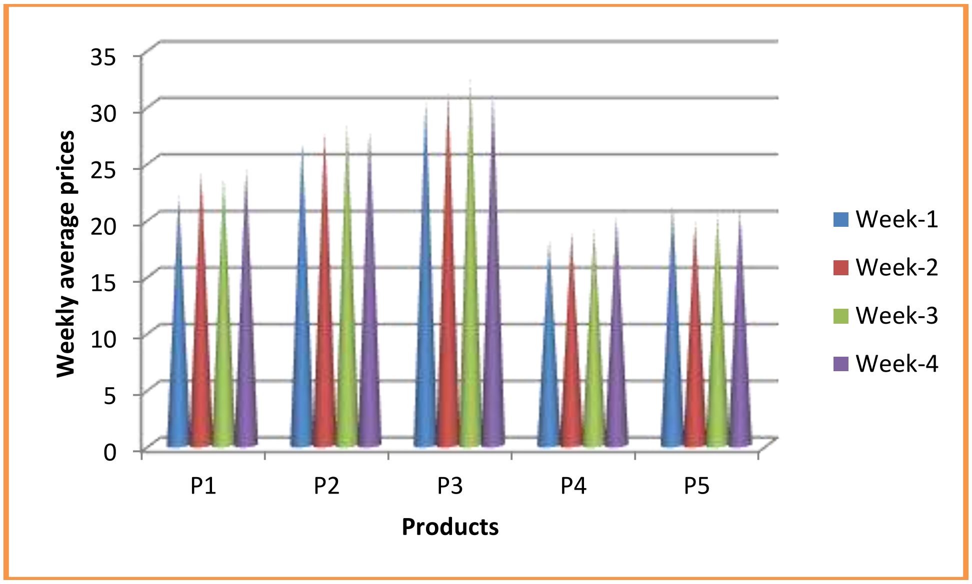

Figure 1. Weekly average market prices of such products in a certain period

To find the solution for this example, the formulated MILP model that is equation (1) gives the following results.

Total profit = 625660
Total revenue = 1426900
Total produced = 51422.7
Total trade = 1426900
Total production cost = 76612.6
Total holding cost = 2334.4
Total transportation cost = 10393.8
Total land cost = 151427
Total labor cost = 263232
Total raw material cost = 191667
Total fertilizer cost = 36329.1
Total others cost = 69180.3

To analyze the result, labor cost is the highest cost, which flows as raw material cost and land cost.

Now, the sensitivity of the labor cost, raw material cost and fertilizer cost clarifies that all the event the increase of the cost then decrease the profit. If we increase 10% of labor cost, raw material cost and fertilizer cost respectively then labor cost changes the profit more than the other two cost and raw material cost changes the profit more than the fertilizer

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cost. From this analysis, we conclude if the labor cost is decreased then the firm level producer will be more profitable. Therefore, labor cost is the main influence on profit, which is increased or decreased.

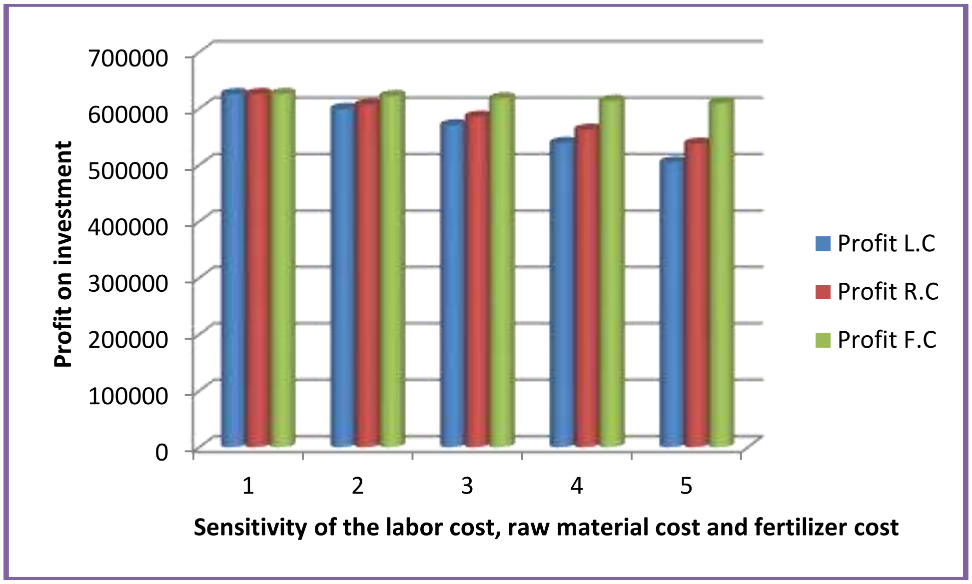

Figure 2. Effect the sensitivity analysis labor cost, raw material cost and fertilizer cost on profit.

From figure3, we conclude that the products 1, 3 and 4 are profitable for all three locations, but product 2 is not profitable for location 2 and product 5 is less profitable for location 3. Also all products are profitable in location 1.

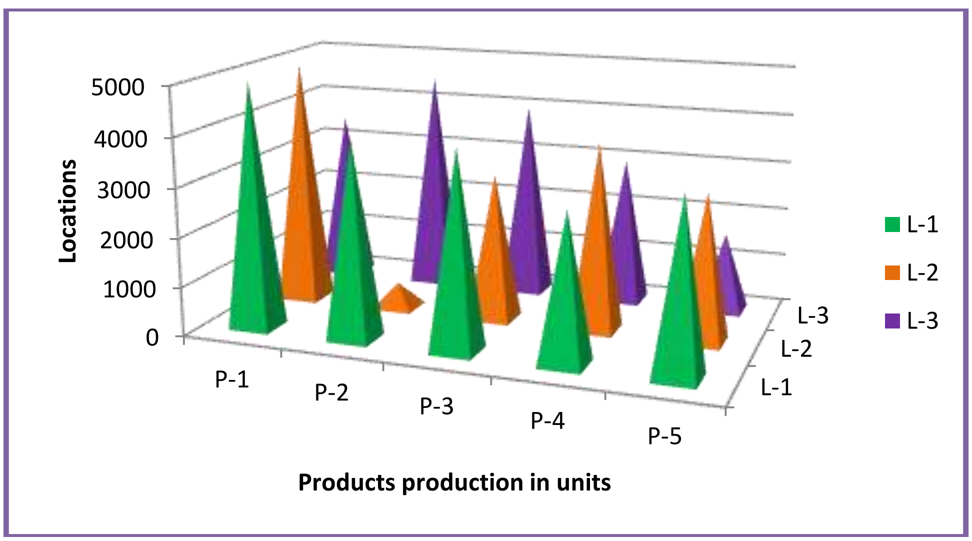

Figure 3. Production of different products in different locations

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Now, we have to analyze the proposed model for demand uncertainty. Consider the demand will be uncertain in three scenarios, which are least demand, maximum perhaps demand and extreme demand will be available with probability 0.60, 0.70 and 0.60 respectively. For these considerations, solving equations (1) and (2), then we have the following findings:

	Least demand	Maximum perhaps demand	Extreme demand
	Probability = 0.6	Probability = 0.7	Probability = 0.6
Case-I	Revenue = 779459 Prod. cost = 47040 Hold. cost = 2334.4 Trans. cost = 5184.12 Land cost = 68525 Labor cost = 126245 Raw material cost = 85491 Fertilizer cost = 22100 Others cost = 25620 **Profit = 238084**	Revenue = 1397110 Prod. cost = 79382.4 Hold. cost = 2334.4 Trans. cost = 9996.52 Land cost = 119698 Labor cost = 210534 Raw material cost = 141617 Fertilizer cost = 37899.1 Others cost = 43986.5 **Profit = 526085**	Revenue = 1456210 Prod. cost = 80042.4 Hold. cost = 2334.4 Trans. cost = 10131.5 Land cost = 120048 Labor cost = 210972 Raw material cost = 141617 Fertilizer cost = 38199.1 Others cost = 43919 **Profit = 485300**
Case-II	Revenue = 752259 Prod. cost = 45000 Hold. cost = 2334.4 Trans. cost = 4844.12 Land cost = 65975 Labor cost = 119700 Raw material cost = 80799 Fertilizer cost = 21080 Others cost = 24855 **Profit = 86655**	Revenue = 1386930 Prod. cost = 77139.6 Hold. cost = 2334.4 Trans. cost = 9494.59 Land cost = 116285 Labor cost = 209506 Raw material cost = 141617 Fertilizer cost = 37202.7 Others cost = 43704.5 **Profit = 333454**	Revenue = 1437170 Prod. cost = 76001.4 Hold. cost = 2334.4 Trans. cost = 9552.77 Land cost = 112453 Labor cost = 210022 Raw material cost = 141617 Fertilizer cost = 36900.8 Others cost = 43763.1 **Profit = 229544**

Table 3: Profit analysis on revenue for various costs

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We have two different equations (2) and (3) from the main equation (1), which are two different mathematical models. To solve equation (2) for the first case, we have to delay, until we do not know the demand. In this case, uncertainty contains everywhere on the production. Solving equation (2), the optimal solution and objective values tabulated in table9, for all three scenarios. Again, solving equation (3) for the second case, where uncertainty affects only the demand on sold products then we get the optimal solution and objective values which are tabulated in table9, for all three scenarios. For the second cases, the farmers know the demands before production, so they decided early which products produce. The production demand for equation (2) and (3) do not any similarity because in first case farmers do not know the demand before production. I think, these results will be helpful for all kind of agricultural products producer.

In figure 4, green and orange color charts are describing scenarios for demand is known before any decisions about the production and demand is known after production. From this figure, we observe that the second scenario is the more profitable other than two scenarios. When maximum perhaps demand will be happen in both cases the profit is very nearest to our expected profit.

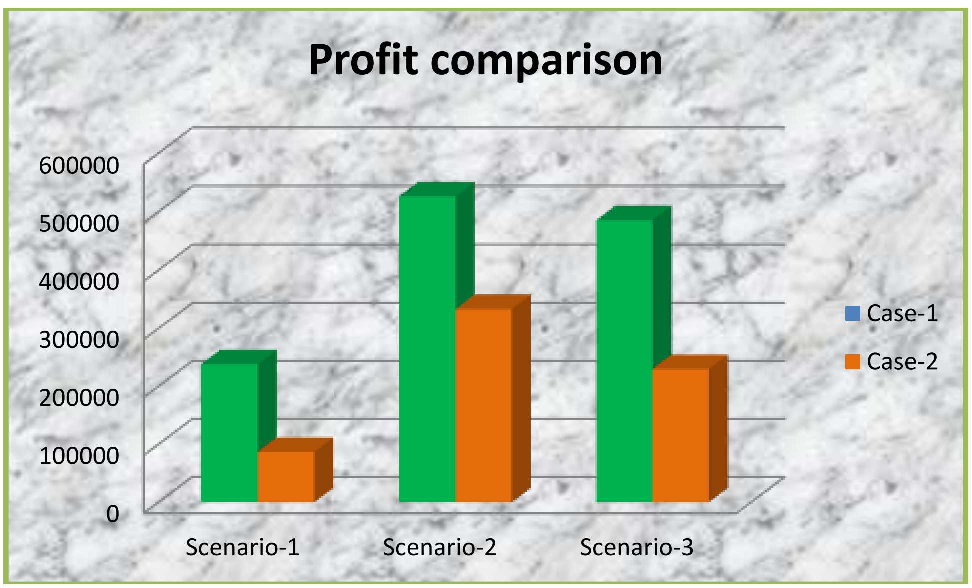

Figure 4: Profit comparison for both cases

But for least demand production will be happen, the profit is very small amount according to our desired profit, which shows in scenario-1. Also, when extreme demand production will be happen, the profit do not extreme for both cases, presents in scenario-3. Therefore, maximum perhaps production demand scenarios get better results.

CONCLUSION

In this chapter, farmers MILP model is developed for profit optimization. The first model is modified into another two models for the case of uncertainty and solved these models by using AMPL with appropriate solver MINOS. This chapter, we consider the demand uncertainty for two cases. Therefore, MILP model could be one of the relevant approaches in a logistic model which seeks to find the optimum manufacturer as well as optimum distribution with profit maximization and cost minimization. It was observed from the agriculture production and sub-sector margin analysis that agriculture production was a profitable business. Some of the significance findings can be summarized as follows:
The illustrated numerical example shows that maximum profit is obtained from our MILP model without uncertainty. But in circumstances of Bangladesh, agricultural business is very uncertainty. Here we discuss three situation of demand uncertainty; least demand, maximum perhaps demand and extreme demand. From figure 4: we conclude that, maximum perhaps demand uncertainty gets the best solution according to our excepted solution. Also, some important finding shows in table 3.
The work may also be expanded along a more progressive environment considering whole supply chain from producer to consumer including various commission agents.

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