一般論文

Awareness of Operational Research in a Developing Country : Focus on Bangladesh

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Abstract

Operational Research(OR) is little known in Bangladesh in either the academic or the business areas. However, some OR studies have been carried out in Bangladesh. These studies are scattered in various journals and documents and are not all easily accessible. In this paper an attempt has been made to bring together some of them.

1. Introduction

The growth of operational Research(OR) in the developing countries has been very slow compared to its growth in the industrialised nations, although the science has been applied in some developing countries for almost as long as in the industries of the developed nations. For example, in Egypt and in India, OR was first used in the 1950s(Elshafei[1], Bandyopadhyay and Varde[2]). Indeed, India, may be considered as the pioneer in applying OR to national planning(Rahman[3]).

Until the early 1970s there were only a few publications describing the education, the practice and the potential of OR in developing countries. Examples from this period are the papers of Morton[4], Muir, Dizy and Faulker[5], Ackoff[6], and Sagasti[7]. Over the last decade, OR for developing countries has been of special concern in both industrialised nations, where the science started, and in developing countries, to which it is being transferred. A rich bibliography has accumulated. Conferences(IFORS[8-11]) have been organised devoted wholely or partly to the subject and several books have been edited(Luck and Walsham[12], Jaswal[13], Luck and Walsham[14]) bringing together Third World OR studies. The main emphasis of the literature has been focused on the following topics :

1. Reports of the application of OR to solve a specific problem in a developing country

(Patel[15], Berghmans, Schooaerts and Te-

ghem[16], Idama and Tomlinson[17]).

2. The identification of possible areas suitable for application of OR and the diffculties associated with its application(McCarthy[18], Kathawala [19], Smith[20]).

3. OR education in and for developing countries (Bandyopadhyay and Varde[2], Walsham[21], Luck and Walsham[22]).

In the majority of these studies it was clear that for successful application, OR must be appropriate to the local context, i.e. appropriate to the people who will use it, relevant to the local problems and close to the local culture where it will be applied. In other words, it is simply not enough to 'transplant' a solution to a problem from one economy or nation to another. For example, the solution to a decision problem in an industrialised country may be to introduce further mechanisation and make workers redundant. In a less industrialised nation, this may not always be acceptable, even if the same economic advantages would apply. Many less developed countries do not have the potential to absorb the kind of workers that would be replaced in a technological revolution into their workforce ; as a result, the priority may be to make a constraint of negligible reduction in the workforce(Clayson[23], Glen and James[24]).

Only a few OR studies have been carried out in the context of decision making in Bangladesh. These are scattered in several journals and documents and so are not easily accessible. In this paper an attempt has been made to bring together some of them in order to give as up-to-date view as possible on OR activities in Bangladesh.

The plan of the paper is as follows. A brief description of the nation is given in the next section to help understand the country's economic base and technological level. The description of some of the OR studies follows with a conclusion and summary.

2. Bangladesh-Some Economic Facts and Statistics

Bangladesh falls into that category of the developing countries which has limited natural and technological resources on one hand and huge population on the other. With a population at 90 million (ESCAP[25]) six times more than Australia, it is the 8th most populous country in the world. It has an area of 144 thousand square kilometres, which is approximately 2% of the area of Australia. Although the country is surrounded by the largest democracy-India, it has been under military rulers almost continually since independence in 1971.

Bangladesh is predominantly an agricultural country. Agriculture accounts for nearly 46% of the GDP and provides employment to 62% of its labour force(BBS[26]). In spite of this, there is a national food deficit. At no time during the last 20 years has the nation produced enough food to provide her population with 446 gms(15.7 oz) of foodgrain (this amount is considered by the government as an acceptable estimate of minimum foodgrain consumption) per head per day(Tarrant[27]). Jute (raw and manufactured) and tea are the two most important exports accounting for 80% of the nation's export income(BBS[26]). The annual per capita income is just over US$ 100.

The country lacks basic communications and service facilities such as health and education in the rural areas where 90% of its population live. There

is only one health facility for every 100 thousand people(BBS[26]). Half the population has a deficient calorie intake and more than 80% are deficient in important nutrients(Institute of Nutrition and Food Science[28]). 80% of the population are illiterate(ESCAP[25]). Enrollment in primary schools is 55-60% of age groups and dropout rates are high(Inslam and Bachman[29]).

Industry is small in Bangladesh and contributes less than 10% to its GDP(BBS[26]). Among industries jute, textile, paper and newsprint, sugar and fertilizers are important. Like the agricultural sector, the performance of the industrial sector is considered to be poor even compared to many less industrialised countries. This is due to inefficient production and poor quality management. The nation has a few proven mineral resources of which natural gas is the important. At present it is being used for power generation and in the fertilizer factories.

Putting together these facts and figures, it is not difficult to identify some of the factors which affect the decision making process in Bangladesh. These factors, quite similar to those mentioned by Kemball-Cook and Wright[30], are as follows :

1. Low levels of infrastructure.
2. Shortage of financial resources.
3. Shortage of skilled human resources.

Sagasti[7, p. 121] has noted that "the most important reason for promoting the use of management sciences in general and OR in particular, in under-developed countries, is that the general lack of resources, particularly human and financial, imposes the urgent need for using them more efficiently". Since Bangladesh is characterised by such a lack of resources, it will be evident that for Bangladesh optimal utilisation of available resources is an urgent necessity.

3. Operational Research Studies in Bangladesh

In Bangladesh the stem 'Operational Research' is little known in both the academic and the business arenas. When the University of Dhaka introduced OR as an option in the MA/MSc Mathematics curriculum in 1969 and a series of lectures was given on OR/game theory by overseas visitors in the same year, it was the first academic recognition of the subject in Bangladesh(Dunford[31]). However, according to Ahmad[32] techniques like forecasting, regression analysis and linear programming were introduced in the department of Economics in Dhaka in 1964. At present two Universities in three different departments and three institutes offer OR as a course at graduate level. The nature of these is to produce generalists. They are taught by conventional methods, with lectures emphasizing basic quantitative techniques. The teachers rely heavily on foreign books, mainly by US authors. There is no OR journal in Bangladesh. However, some OR studies have been published in the Journal of Management Business and Economics, produced by the Institute of Business Administration, in Dlhaka(Hassan[33], Brahmbhatt, Jaiswal and Jani[34], Mahmud[35]).

In this section some of the OR studies undertaken in the context of Bangladesh will be discussed. Agriculture is the most important industry in Bangladesh ; it is therefore not surprising that most of the studies are related to agriculture and agricul-

tural development.

3.1. The Bangladesh Agricultural Model

The Centre for World Food Studies(CWFS) at the Free University of Amsterdam has constructed several simulation models for the analysis of food production and distribution in developing countries. The Bangladesh Agricultural Model(BAM) (Rebelo[36]) is one such model.

By dividing the population into 10 groups depending on their occupation, land ownership status and residential location, the model essentially traces the effects of alternative policies on these socio-economic groups. The BAM is a complex model consisting of three main components ; supply, exchange and agriculture. The model may be summarised as follows. In the supply part of the model, each of the 10 groups draw up their own production plans on the basis of several factors : price expectation, knowledge of technology and availability of land, labour, capital, livestock etc. These factors lead them to choose, out of wide range of production activities, the combination promising the best return to them.

At the end of the production process(which is assumed to take one year), all producers, i.e. each of the 10 groups, supply their commodities to the market. Here the suppliers are confronted with the demands of each socio-economic group and an interchange takes place. The government can intervene in this process through its financial and market policies. The interaction of supply, demand, external trade and government interventions results in te setting of prices for all commodities. These in turn determine incomes and their distribution, the purchasing power and the food intake of each socio-economic group. At the same time, these prices have an impact on the price expectations for the next year, which guide production plans. At the end of the exchange process, adjustments take place in the resources available to each group, thus setting the stage for the new production plans and for supplies to enter the market in the next year.

The model has been applied in comparative static analyses of various issues : alternative levels of fertilizer subsidy, alternative policies on flexible food rationing(a type of national ration scheme directed towards the lower incom socio-economic group), shortrun impact of trade liberalization measures and the stabilization of the Bangladesh jute market. The model has been used to support the preparation of the Third Five-Year Plan(1985-90) and the Perspective Plan(1985-2000) (Rebelo [36]).

3.2. The Bangladesh Grain Model

In 1974-75 a team of Danish experts participated in a nation-wide logistics project which was initiated by the govenment of Bangladesh and funded by the World Bank. The purpose of the study was to recommend the solution—both technically and economically—to the country's grain supply and storage problems. The study resulted in an extensive report of five sections. The Bangladesh Grain Model is the third section of the report(Pruzan [37]).

A large scale mixed interger programming model is used to define the number, size, and location of grain storage facilities in Bangladesh. It was

possible to vary the assumptions regarding supply and demand of foodgrain and transportation and handling systems. The aim was to select Major Storage Facility(MSF) sites and a distribution system. It was formulated as a network flow problem. The grain is considered to flow from surplus areas and outer anchorage, if imported-through MSFs to deficit areas-and to outer anchorage, if exported. However, due to the size of the network(approximately 600 vertices and 6000 arcs) and the number of fixed cost elements(approximately 200), a single optimal solution was not identified. Instead a set of solutions(under different assumptions) was proposed.

The model output suggested several recommendations with respect to the location of sites for MSFs and their capacity and the allocation of demand points to these MSFs. The major recommendations of the study were implemented in stages.

3.3. A Nutrition Model for Bangladesh

The Bangladesh Nutrition Model(Rahman[38]) is a simple linear programming model which minimizes the cost of imports or maximizes the value of exports, under nutritional requirements. The decision variables considered are the type of crop or corpping pattern to be produced in different parts of the country. The model was applied at village and regional levels. Two villages, Shitalpur and Kulia-Durgapur of Khulna District were considered for the village level study. The country was divided into seven homogeneous regions for the regional level study. Taking into consideration the malnutrition situation in Bangladesh, three problems were considered :

1. The constraints were to satisfy the requirements of two dietary components : energy(calories) and protein. It was assumed that all arable lands, defined to be those that are used at any time of the year for cultivation, are available throughout the year.

2. Problem 1 was repeated with constraints on nutrients and vitamins.

3. In the final problem, the assumption that all arable lands are available throughout the year was released. Instead, it was assumed that inadequate irrigation and flood control technologies limit the amount of land available during winter and summer months to that currently being used.

It was evident from the results that both villages could achieve nutritional self-sufficiency if problem 1 and 2 are considered. In the case of problem 3 only Kulia-Durgapur could achieve self-sufficiency. It is however, interesting to note that the net value of exprots from Kulia-Durgapur is approximately equal in value to the net aid requirements in Shitalpur. This emphasises the distribution aspect of the nutritional problem. It indicates that acting together both the villages could achieve self-sufficiency even if only the existing land areas utilized in winter and summer season are available for cultivation. However, sefl-sufficiency for the regions can only be achieved with the current population level, provided there is full flood control and effective irrigation policies. This conclusion does not come as a surprise, since flood control and irrigation are the two most important factors affecting agricultural activities in Bangladesh.

3.4. Analysis of the Second Five-Year Plan

In 1980 the Government of Bangladesh introdu-

ced its Second Five-Year Plan(1980-85) in order to improve its economic growth, reduce unemployment and decrease the trade deficit. The planning model that the government used was essentially a static input-output Leontief model. In a study of this model, Quaddus and Holzman[39] reported on the use of an interactive multiobjective linear model to analyze the same problem as was considered in the Plan. The model was basically of a forecasting type with three objectives :

1. Maximize GNP growth.
2. Minimize trade deficit.
3. Maximize percentage employment.

In the absence of actual Bangladeshi planners, five pseudo decision-makers were engaged to solve the planning model interactively. These decision-makers, however, had no familiarity with the interactive approach to problem solving. Nevertheless, they had detailed information about the problem they were dealing with, because of their previous experience with the government. After making several trade-offs between the objectives, the pseudo decision-makers reached an efficent solution. However, no comparison was drawn with the results of the government's input-output model. The purpose of the whole exercise was to demonstrate the merits of using an interactive multiobjective approach to macroeconomic planning problems over other techniques, specifically single objective optimization techniques.

3.5. A Simulation Study of Crop Water Requirement

When natural sources of water, e.g. rains, together with the available soil moisture cannot meet the water requirement of crops, the difference can be met through irrigation. In this study Chowdhury, Huq and Hassan[40] developed a simulation model to determine the level of irrigation required in different parts of Bangladesh over a planning period of one year. The model considered that the need for crop water would depend on the following parameters :

1. Total rainfall.
2. A vailable soil moisture.
3. Evapotranspiration.
4. Percolation.

The parameters rainfall and available soil moisture can be considered as input and evapotranspiration and percolation as output of the system. Thus the amount of water required for crop during any time period will depend on the differences of input and output. The model is applied to a project area consisting of 18 Upazillas(as Upazila comprises an area of approximately 250-300 square kilometres) in Bangladesh. Using data on soil properties, rainfall, available soil moisture and considering ponding depth the model calculates the requirement of water for 13 different crops and cropping patterns cultivated in that project area and demonstrates the consequence of inadequate moisture on the crop yield.

The model has been developed as a part of the study undertaken by the Master Plan Organisation, Ministry of Irrigation, Drainage and Flood Control, Government of Bangladesh.

3.6. Inventory Analysis at Bangladesh Machine Tools Factory

Bangladesh Machine Tools Factory(BMTF) is the only one of its kind in Bangladesh. It is a large organisation with a wide range of facilities to produce various types of machine tools. At the time of its commissioning in 1968, the idea was to feed different manufacturing organisations with its products in both parts of Pakistan. Since 80% of the nation's manufacturing companies were situated in West Pakistan(now Pakistan), BMTF lost its major market with the independence of Bangladesh in 1971. The management of BMTF failed to identify the range of products to be produced for the local market ; it failed to design a product forecast plan in accordance with the country's industrial policies. It had no marketing strategy. Before 1982 it lacked a basic production plan. Until then the factory was manufacturing products of various kinds in small quantities to order. Considering that there would be further orders for these products in future, the management purchased raw materials in bulk quantities to minimise total procurement cost. It appeared from the documents that either there was no further demand for these products or the demands were sporadic. Hence, no effective control of stock could be planned and implemented and as a result a huge inventory piled up.

In 1985 the Bangladesh Management Development Centre(BMDC)[41] carried out an inventory management study for BMTF. The purpose was to formulate an inventory plan which would be in consistent with the production plan, keeping the investment in inventories as low as possible.

First, the items in the inventory were categorized on the basis of their current usage in production into following groups :

1. Continuous use items－items which had been used continuously for the preceding 3 to 4 years.
2. Sporadically used items.
3. Never used items－items, which had never been used after purchase.

About 12000 items were covered in the study. Out of these, roughly 800, 7600 and 3600 items were identified as continuous, sporadic and never used items respectively.

An ABC analysis was done for the continuous use items. Only seven items were categorized as class A items ; they constituted 80% of the total inventory value. Another 38 items were class B items, accounting for 15% of the total inventory value. It was suggested that by proper control and planning on these 43 items the management of BMTF could effectively control 95% of their investment in stock. The study also made several suggestions regarding other groups of tiems.

3.7. Simulation for Irrigation Planning

At present the use of computers in Bangladesh is very limited and is mainly for data processing. Their application in mathematical programming is confined to a handful of foreign-aided projects. Chowdhury[42] gives one of these. He reports on the experiences of using a micro-computer for simulating an optimisation problem which involved allocation of funds among alternative investment schemes in irrigation planning in Bangladesh.

The problem is formulated as a linear programming model for a planning period of 20 years with constraints on the budget, availability of groundwater and sustainability of a particular irrigation scheme in the form of operation and maintenance

costs. Its objective function maximizes the total benefit(in terms of increased yield) achievable by bringing non-irrigated land under different irrigation schemes. However, the model turned out to be a large one, involving 18000 decision variables and the LP was not solved directly. A simulation approach was used instead.

The result of the model showed the change in the land pattern under differnet development schemes and the related increase in the foodgrain production over a 20 year period. It demonstrated that development would cease after about 15 years which would indicate a saturation point in land development. The time period of 15 years could be changed by varying the budget constraint. These flexibilities give the model an ability to meet the short and long term targets of the country within the perspective of development.

3.8. Evaluation of Investment Policies in Irrigation

The study by Smith[43] reports on the experience of using several decision rules to evaluate investment requirements and economic returns in designing irrigation projects in Bangladesh. In some respect, the study is similar to the one discussed earlier(Chowdhury[42]), which is formulated as a linear programme. In this case, however, a stochastic programming model is constructed.

The stochastic model has not been solved optimally. Instead, by applying chance-constrained programming, deterministic equivalents to the probabilistic water requirement constraints were derived and using decision rules good sub-optimal solutions to the problems were obtained. These decision rules are :

1. Zero-order rules.
2. Linear rules.
3. Piecewise linear rules.

The solution of the model using these rules produces two sets of decisions to optimise the benefits from an irrigation project. These are related to investment and operating decisions. The operating decision variables considered in the model are : amount of groundwater pumped and delivered(removed) to (from) the project area, amount of surface water diverted from the river to the irrigation fields and area sown to crops. The chance-constrained programming model, using zero-order rules, executes the investment decision only. Operating decisions are considered to be invariant from year to year. In the case of linear and piecewise linear rules however, the model treats operating decisions as stochastic policies to be determined by the model solutions. The model was applied to an irrigation project in Bangladesh considering five different crops over six decision periods. The comparison of the solutions using different decision rules indicated that the investment decisions are not significantly affected. For example an adoption of the project configuration suggested by the two-piece rules would lead to a savings of about 1% in construction costs compared to the linear solutions. The savings are even less when the zero-order solution and the two-piece solution are compared. However, the model is useful for computing benefits for comparison with other projects.

4. Conclusion

Apart from the isolated studies discussed above,

OR is little known in Bangladesh. However, from our earlier discussions, it appears that some awareness is developing among the academics, planners and decision-makers. Nevertheless, there are some who seem to be more concerned with the degree of sophistication of the technique and have serious doubts about its application possibility. The Management Education Review Committee of Bangladesh expressed the view that OR cannot be applied in Bangladesh because the country is not yet ready for that degree of sophistication(Bandyopadhyay and Varde[2]). It is probable that they were considering the use of computer-based packages and mathematical models, and not on the more general methodology of OR. Rather, the use of elegant mathematical models and complicated computer programmes is an exception(Ravn and Vidal [44]) and the success of OR in bringing about major improvements need not rely on sophisticated models(Walsham[21]) or on the involvement of foreign trained OR analysts(Smith[45]).

In the literature, several approaches of OR have been proposed as appropriate for developing countries. These include the participatory planning approach(Ackoff[46]), "barefoot ORSA" approach (Luck[47]) and the use of simple techniques for standard problems(Walsham[21]). The participatory approach recognizes the importance of political factors for effective implementation of OR projects. This has been reported in two separate studies in developing countries(Patel[15], Sissouras [48]). The "barefoot" approach advocates the use of simple OR and system analysis combined to address unstructured problems. Learning from the success and failure of applying OR in other developing countries and using the synthesis of some of these approaches, Bangladesh will find its own way of spreading the awareness of OR in her social and business environment.

References

[1] A.N. Elshafei, OR in developing economies : some experience with applying OR in Egypt's national planning studies, in K.B. Haley (ed.), *Operational Research '75*(North-Holland, Amsterdam, 1976).

[2] R. Bandyopadhyay and S.D. Varde, OR education and developing economies with special reference to India, *Journal of Operational Research Society* 31(1980) 675-687.

[3] A. Rahman, Operational research in India-some questions, *Opsearch* 5(1968) 177-179.

[4] G. Morton, Linear programming-an application in an Indian textile mill, *Operational Research Quarterly* 9(1958) 198-206.

[5] A. Muir, M. Dizy and C. Faulkner, Operational research in Chile, *Operational Research Quarterly* 15(1964)303-316.

[6] R.L. Ackoff, The role of research in underdeveloping countries, *Operations Research* 16(1968) 717-726.

[7] F.R. Sagasti, Management science in an underdeveloping country : The case of operations research in Peru, *Management Science* 19(1972) 121-131.

[8] IFORS, *the Seventh International conference on Operational Research*(Tokyo, kyoto, Japan, July 17-23, 1975).

[9] IFORS, *the Ninth International conference on Operational Research*(Hamburg, F.R.G. July 20-24, 1981).

[10] IFORS, *the Tenth International conference on Operational Research*(Washington D.C, USA, August 6-10, 1984).

[11] IFORS, *the Eleventh International conference on Operational Research*(Buenos Aires, Argentina, August 10-14, 1987).

[12] G.M. Luck and G. Walsham(ed.), *Selected Readings in Operational Research for Developing Countries*(Operational Research Society, Birmingham, U.K, 1982).

[13] N.K. Jaiswal, (ed.), *OR for Developing Countries*(Operational Research Society of India, Delhi, India, 1985).

[14] G.M. Luck and G. Walsham, *Operational Research Applications in Development Management* (Commonwealth Secretariat, London, 1987).

[15] N. Patel, Locating rural social service centers in India, *Managements Science* 25(1979) 22-30.

[16] L. Berghmans, P. Schooaerts and J. Teghem Jr., Implementation of health facilities in a new city, *Journal of Operational Research Society* 35(1984) 1047-1054.

[17] I. Idama and R. Tomlinson, The prospect for OR in the Nigerian Government Service-an administrators viewpoints, *Journal of Operational Research Society* 37(1986) 195-202.

[18] S.J. McCarthy, Potential applications of OR in developing countries-a generalisation from Botswana, *Journal of Operational Research Society* 29(1978) 167-170.

[19] Y. Kathawala, Operations research in developing countries—Suggestions for successful implementation, *Indian Management* August(1985) 20-26.

[20] D.K. Smith, Operational research in a developing country : The case of Jordan, *Journal of Operational Research Society* 38(1987) 577-584.

[21] G. Walsham, Education in operational research for the developing countries, *Journal of Operational Research Society* 29(1978) 299-306.

[22] G.M. Luck and G. Walsham, A teacher's network for Third World OR, *Journal of Operational Research Society* 37(1986) 211-216.

[23] J. Clayson, How relevant is Operational Research to development ? The case of Kenyan industry, *Journal of Operational Research Society* 31 (1980) 293-299.

[24] M.T. Glen and C.F. James, Difficulties in implementing management science techniques in a Third World setting *Interfaces* 10(1980) 39-44.

[25] ESCAP, *Population of Bangladesh*, Country monograph series no.8(United Nations, New York, 1981).

[26] BSS, *Statistical Yearbook of Bangladesh* (Statistics Division, Ministry of Planning, Dhaka, Bangladesh, 1986).

[27] J.R. Tarrant, Food policy conflicts in Bangladesh, *World Development* 10(1982) 103-113.

[28] Institute of Nutrition and Food Science, *Nutrition Survey of Bangladesh 1975-76*(University of Dhaka, Dhaka, Bangladesh, 1977).

[29] K. Islam, and S. Bachman, PHC in Bangladesh-too much to ask ?, *Social Science and Medicine* 17(1983) 1463-1466.

[30] D. Kemball-Cook and D.J. Wright, The search for appropriate OR : A review of operational research in developing countries, *Journal of Operational Research Society* 32(1981) 1021-1037.

[31] F. Dunford, Management Science round up, *Interfaces* 12(1982) 33-34.

[32] M. Ahmad, Personal communication, 19

87.

[33] M. Hassan, Operations research in decision making, *Management Business and Economics* 2(1976) 95-107.

[34] A.C. Brahmbhatt, M.C. Jaiswal and B.B. Jani, EOQ inventory model under the influence of variable mark-up of prices, *Management Business and Economics* 6(1980) 188-200.

[35] K. Mahmud, Mathematical programming model for cash-flow estimation of complex industrial production system, *Management Business and Economics* 6(1980)148-161.

[36] I. Rebelo, Economy-wide models for developing countries, with emphasis on food production and distribution, *Journal of Operational Research Society* 37(1986) 145-165.

[37] P.M Pruzan, The Bangladesh grain model, *European Journal of Operational Research* 3(1978) 110-121.

[38] S. Rahman, *A Nutrition Model for Bangladesh*, Unpublished M.E Research Study, IE. 83-14(Asian Institute of Technology, Bangkok, Thailand, 1983).

[39] M.A. Quaddus and A.G. Holzman, Interactive approach to macroeconomic planning with multiple objectives : Results of an experiment, in N.K. Jaiswal(ed.), *OR for Developing Countries* (Operational Research Society of India, Delhi, India, 1985).

[40] I.G. Chowdhury, M. Huq and A. Hassan, A simulation study of crop water requirement, *Paper presented at the Bangladesh Economist Association Bi-annual conference*, Dhaka, Bangladesh, July 14-16, 1988.

[41] Bangladesh Management Development Centre, *Bangladesh Machine Tools Factory : Report on Inventory Analysis*(Dhaka, Bangladesh, 1985).

[42] I.G. Chowdhury, A simulation model for micro-computer, *Journal of Management Business and Economics* 12(1986) 262-270.

[43] D.V. Smith, Decision rules in chance-constrained programming : some experimental comparisons, *Management Science* 19(1973) 688-702.

[44] H.F. Ravn and R.V.V. Vidal, Operational research for developing countries-a case of transfer of technology, *Journal of Operational Research Society* 37(1986) 205-210.

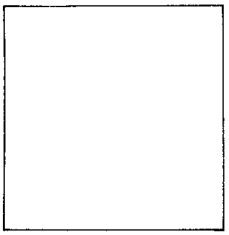
[45] J.D. Smith, Management science in developing countries, *Management Science* 20(1973) 255-256.

[46] R.L. Ackoff, National development planning revisited, *Operations Research* 25(1977) 207-218.

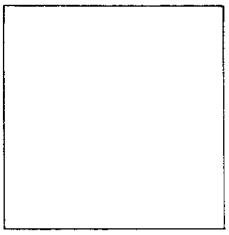
[47] G.M. Luck, Barefoot ORSA, in K.B. Haley(ed.), *Operational Research '78*(North-Holland, Amsterdam, 1978).

[48] A. Sissouras, In search of an effective management science application in a developing country-The case of Greece, *Omega* 16(1988) 249-258.

저자소개



저자(shams-ur Rahman)는 방글라데시 다카시에 있는 다카대학교의 경영대학에서 생산운영관리(Production and Operation Management) 분야의 조교수이며 영국 엑시터시에 있는 엑시터 대학의 수리통계 및 O.R. 학과의 동료 연구원이다. 그는 타이의 방콕에 있는 Asian Institute of Technology(AIT)에서 산업공학 및 관리에서 공학석사(ME) 학위를 수여 하였고, 소련의 기계공학 분야에서 이학석사(MSC)학위를 받았다. 그의 연구 관심 분야는 공공시설 배치 문제와 산업 및 서비스 생산성 분야이다.



공동저자(David k. Smith)는 영국의 엑시터 대학의 수리통계 및 O.R. 학과의 강사이다. 그는 랭커스터 대학에서 O.R.을 연구하였으며 1977년에 박사학위를 받았다. 그는 랭커스터 대학에서 O.R.과 통계적 분석에 관한 여러편의 논문을 비영리 단체에 싣고 있다. 그는 "Network Optimisation Practice : A Computational Guide"(1982)의 저자이다. 1985~86년 동안 암만에 있는 요르단 대학의 교환교수 였다.