VOTER SATISFACTION MAXIMIZATION IN PROBLEMS OF RESOURCE ALLOCATION

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Abstract

This paper describes a group method of allocating a given resource budget over a set of n items. The method frequently satisfies considerably more than half of the votes cast by the members of the group, "satisfies" in the sense of allocating to an item at least the amount asked for by the voter.

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Introduction

The two main purposes of this paper are: to serve as a record of some exercises conducted during the first three seminars of the graduate-student program offered at IIASA during the summer of 1978, with a view to possible repetition of this type of exercise on future occasions; and to describe a group method of resource allocation that may be as useful in real-world decision-making as it is classroom demonstrations.

The first three workshop seminars dealt with the following three related methodological problems:

A: How to form some idea of the major respects in which the world of 2000 will be different from the world of today.

B: How to identify some of the major issues with which the world's decision-makers will be faced during the remainder of this century.

C: How an international research organization such as IIASA might approach the task of allocating its resources over the issues identified under B in order to contribute most effectively to their satisfactory resolution.

Task A

The first task, of forming some idea of the major respects in which the world of 2000 will be different from the world of today, was handled in two stages. First, the fictitious assumption was made that a clairvoyant would be available to the class to whom just 10 questions about world conditions in the year 2000 could be posed, where the form of each question was to be such as to call either for a yes/no answer or for a single numerical response.

After nominating more than 10 questions and editing them with some help from their instructor, the group decided, by ranking all questions according to their perceived importance, to select the following 10 questions:

1. What will be the per-capita food supply in the year 2000 of the world's 20 percent least well-fed people, using an index value of 100 for 1978?
2. What is the probability that there will have been a major technological breakthrough in energy that promises to lead to a new dominant source of energy?
3. What is the probability that the equitability of different nations' access to energy and mineral resources will have improved?
4. What percentage of the world's population will live in countries having a centrally planned, socialist economy?
5. What will be the size of the world population (in units of 10^9)?
6. What will be the annual percent increase in the world population?
7. What will be the degree of pollution, using a scale from 0 (= no pollution) to 100 (= all life extinct) and assuming arbitrarily a value of 25 for 1978?
8. What will be the per-capita amount of known renewable resources, using an index value of 100 for 1978?
9. What will be the world average per-capita income, in 1978 monetary values, using an index value of 100 for 1978?
10. What will be the ratio of the per-capita income among the highest-paid quintile of the world's population to that among the lowest-paid quintile?

Next, due to the unfortunate absence of a suitable clairvoyant, each student was asked to provide estimated answers to these questions. The medians of the 13 participants' responsed were as follows:

1.	105	2.	.80	3.	.30	4.	50	5.	6.5
6.	2	7.	35	8.	100	9.	120	10.	41

Of course, not even the students themselves would claim great reliability for these estimates; yet the process of arriving at the questions required a healthy systems-analytical attitude, and the formulation of the questions as well as the attempt to answer them gave rise to a thoughtful debate that set the tone for addressing the next task.

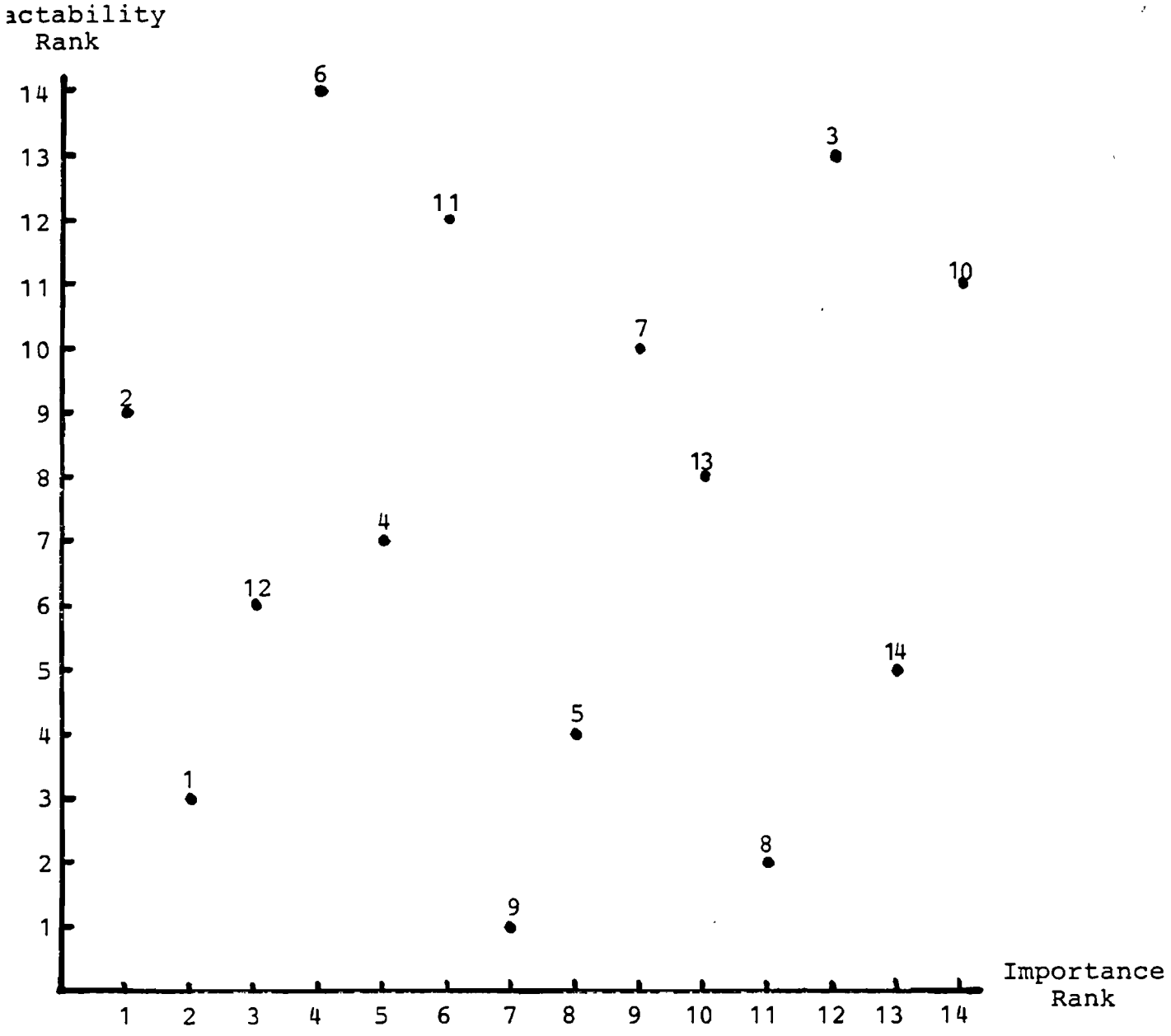
Task B

The second task was to identify some of the major issues with which the world's decision-makers will be faced during the remainder of this century. In this case, the students were provided with a

list of 10 potential issues, to which they added 4 others. They were then asked to rank the entire set of 14 issues according to their importance as well as according to their importance as well as according to their tractability, the latter in the sense of the relative ease with which a satisfactory resolution of the issue might be attained.

The issues, together with their group rankings, are listed below:

	Importance rank	Tractability rank
1. What, if anything, needs to be done to avert large-scale famines?	2	3
2. What safe methods are there of supplying enough energy to meet future global demand?	1	9
3. What international action could be taken to counter acts of terrorism?	12	13
4. What measures need to be taken to assure an adequate global supply of clean water?	5	7
5. What measures need to be taken globally to reduce air pollution?	8	4
6. What, if anything, needs to be done to halt the depletion of non-renewable resources?	4	14
7. What can be done to halt the gradual increase of the desert areas in the world?	9	10
8. What plans should be made to build new cities for housing billions of additional people?	11	2
9. What actions by the developed countries could be taken to aid the developing countries in providing adequate medical and educational facilities for their rapidly grwoing populations?	7	1
10. What controls, if any, need to be set up to guide imminent developments in human genetics in directions beneficial to mankind?	14	11
11. What can be done to persuade people to change their value system so that the global ecology will be better protected?	6	12
12. What measures need to be taken to halt the population explosion?	3	6
13. How can a global reallocation of resources from military to nonmilitary purposes be promoted?	10	8
14. How can the growing influence of technology on societal developments, both national and international, be brought under better control?	13	5


actability
Rank
14
13
12
11
10
9
8
7
6
5
4
3
2
1
6
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7
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8
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1 2 3 4 5 6 7 8 9 10 11 12 13 14
Importance
Rank

Task C

Having thus formed some image of what to expect of the future, in terms both of important global developments and of the major issues facing the world, the students had set the scene for the third task, namely, of reflecting on how an international research organization such as IIASA might allocate its resources over the identified issues in an effort to contribute to their satisfactory resolution.

Since a research organization, even if its emphasis is on applied research, cannot devote itself solely to substantive problems as such, to the exclusion of general methodological work, the following additional research item was included in the list to be considered:

15. What systems-analytical methods can be developed and promoted that may be an effective aid in resolving some of the issues numbered 1 to 14?

The students were now askde to decide how they would allocate 100 points of research effort over these 15 items. Since such an allocation might well be different depending on the total resources budget available, it was suggested that they think of having to disburse the research equivalent of 10 million dollars a year for a period of 10 years, so that each percentage point represented 1 million dollars.

The allocation was carried out in two phases. In Phase 1, the group (of 12 students) was divided into 4 subpanels, with each panel having to agree on an allocation. The results were as shown on the left of the following tabulation:

Item	Panel A	B	C	D	Ascending allocation				Group allocation
1	13	15	10	12	10	12	13	15	15
2	12	15	25	20	12	15	20	25	15
3			.5	2			.5	2	2
4	4	4	10	8	4	4	8	10	4
5	6	3	10	10	3	6	10	10	6
6	6	4	2	6	2	4	6	6	6
7		4	1	4		1	4	4	4
8	10	4	5	6	4	5	6	10	6
9	8	15	1	10	1	8	10	15	10
10		1	2	5		1	2	5	2
11	3	5	7.5	4	3	4	5	7.5	7*
12	10	14	15	7	7	10	14	15	10
13	10	1	5	4	1	4	5	10	5
14	3		1	1		1	1	3	3
15	15	15	5	1	1	5	15	15	5
					48	80	119.5	152.5	100

In the column headed "Ascending allocation" the amounts allocated to a particular item were reordered in ascending order. Column summation shows the second column to be the largest one not exceeding the total budget of 100. From this the group allocation in the last column is obtained by distributing the remaining 20 points according to the principle of maximizing the marginal utility of their allocation, "utility" in the sense of capturing as many additional votes as possible. The dotted line shows, on its left, all those votes which were satisfied by the resulting allocation by having at least as much of the budget allocated to that item as they had recommended.

The allocation recommendations to the left of the dotted line amount to about 76% of all 60 such recommendations. [* Note that 7.5 allocated to item 11 was rounded down to 7, which, for purposes of the voter satisfaction computations, was counted as a 3/4 satisfaction.] Thus it may be said that the group allocation computed by this method succeeds, in this case, in satisfying 76% of the votes cast.

Next, after the above table was displayed to the group, a brief debate was encouraged regarding those issues (notable 2,4,5, 9, 12, 13, 15) where there was evidence of a sizeable dissensus between the subpanels. Thereupon, in Phase 2, having listened to each others' arguments, each student was asked to submit his or her separate, revised recommendation for the allocation of the research budget. The results are shown below, together with the new group allocation computed as before; in this case the voter satisfaction index was 67%:

Item	Individual												Ascending allocation												Group alloc
	1	2	3	4	5	6	7	8	9	10	11	12													
1	15	13	15	10	10	10	12	15	10	15	10	13	10	10	10	10	10	12	13	13	15	15	15	15	12
2	21	18	15	20	15	20	10	15	12	16	20	18	10	12	15	15	15	16	18	18	20	20	20	21	16
3	2	2		.5							2										.5	2	2	2	0
4	5	7	6	10	4	5	3	5	4	6	9	3	3	3	4	4	5	5	5	6	6	7	9	10	5
5	6	8	6	10	10	5	6	4	2	6	7	25	2	25	4	5	6	6	6	6	7	8	10	10	6
6	2	6	6	5	4	5	6	5	6	6	6	5	2	4	5	5	5	5	6	6	6	6	6	6	6
7	2	4	5	1	4	5		4		7	4	25			1	2	25	4	4	4	4	5	5	7	4
8	6	5	6	10		6	10	6	10	5	6	9		5	5	6	6	6	6	6	9	10	10	10	6
9	2	7	10	6	15	10	10	12	13	9	8	12	2	6	7	8	9	10	10	10	12	12	13	15	10
10	2	5		1		2					2	4						1	2	2	2	4	5	0
11	8	4	5	5	3	7	3	6	3	6	3	5	3	3	3	3	4	5	5	5	6	6	7	8	5
12	15	7	10	10	15	5	11	11	7	15	7	10	5	7	7	7	10	10	10	11	11	15	15	15	11
13	6	5	5	6	5	7	10	6	12		6	1		1	5	5	5	6	6	6	6	7	10	12	6
14	3	2	5	.5		3	3		6		2	5				.5	2	2	3	3	3	5	5	6	3
15	5	7	5	5	15	10	15	11	15	15	8	10	5	5	5	7	8	10	10	11	15	15	15	15	10
																		97	103						100