World Academy of Science, Engineering and Technology
International Journal of Civil and Environmental Engineering
Vol:2, No:12, 2008

Info-participation of the Disabled Using the Mixed Preference Data in Improving Their Travel Quality

Y. Duvarci and S. Mizokami

***Abstract*—**Today, the preferences and participation of the TD groups such as the elderly and disabled is still lacking in decision-making of transportation planning, and their reactions to certain type of policies are not well known. Thus, a clear methodology is needed. This study aimed to develop a method to extract the preferences of the disabled to be used in the policy-making stage that can also guide to future estimations. The method utilizes the combination of cluster analysis and data filtering using the data of the Arao city (Japan). The method is a process that follows: defining the TD group by the cluster analysis tool, their travel preferences in tabular form from the household surveys by policy variable-impact pairs, zones, and by trip purposes, and the final outcome is the preference probabilities of the disabled. The preferences vary by trip purpose; for the work trips, accessibility and transit system quality policies with the accompanying impacts of modal shifts towards public mode use as well as the decreasing travel costs, and the trip rate increase; for the social trips, the same accessibility and transit system policies leading to the same mode shift impact, together with the travel quality policy area leading to trip rate increase. These results explain the policies to focus and can be used in scenario generation in models, or any other planning purpose as decision support tool.

***Keywords*—**Transportation Disadvantaged, Disabled, Mixed Preference, Stated Preference Data.

I. Introduction

THE transportation community has long been tackling with the issue of improving the worsening travel conditions of the transportation disadvantaged (TD), and specifically the elderly and disabled. The success has been little to improve the TD, whereas the rate of elderly and disabled populations is increasing in many developed nations as Japan. Thus, some literature emphasized the role of participation of those needy groups themselves in the planning and decision-making process for real success for whom the required policies and infrastructure are considered [1], [2]. Insufficient funds and high costs of special treatment for the TD and costly provision of the special services enforce decision-makers to search for cost-effective, time-saving, appropriate, and feasible solutions through novel approaches, promising at the same time the same service quality to the concern groups. Lately, underpinning the coordination issue, clearer "elements of success" are warranted as the new agenda for effective policy-making involving the probable utility of new ITS-technologies and high capacity computers [3], [4] to especially heighten transit quality for the special groups as the disabled. Meanwhile, the Recife Declaration in 1996 supported the right of poor in decision-making and in planning impacting them [1], so, the pro-poor initiatives to be taken thereof.

This paper, therefore, addresses the question of effectiveness in collection and evaluation of the viewpoint of the disabled individuals and an effective way of gaining "information type participation" (info-participation) to involve their reactions into planning and decision-making. The reactions are assumed to be "realizable" events. One approach could be the direct asking of solutions and the impacts to those groups themselves *in situ*. The planner should not be the sole decision-maker about solutions on behalf of those groups, but rather the facilitator in revealing out of their preferences.

The proposed method will base on a simplified mixed stated and revealed preference (S&RP) data of the target groups from a case area. A 1400-person data are obtained from the general household surveys involving preference-revealing questionnaires, in order to integrate these opinions into decision-making for a set of probable policy choices (defined as "variables" or if-conditions). Classifying and ordering these preferences by impact types and importance would provide a basic metric in ranking the best policy options. While the high scored preferences observed refer to the highlighted necessity of policy measure(s), the lowest ones the least.

The existing situation and preferences of the disabled groups will be analyzed within the context of the TD modeling paradigm (as continuation of the recent study of Duvarci and Yigitcanlar, 2007) assuming that the disabled are one of the major sub-categories of the TD. Thus, first, the

Y. Duvarci is with the Izmir Institute of Technology, Izmir, Turkey (corresponding author to provide phone: +90-232-7507044; fax: +90-232-7507012; e-mail: yavuzduvarci@iyte.edu.tr).
S. Mizokami, is with Kumamoto University, Kumamoto, Japan. (e-mail: smizo@gpo.kumamoto-u.ac.jp).

general TD category will be defined through cluster analysis statistical tool of SPSS 11^{TM}, and then the preferences of those disabled falling under the category of the TD will be evaluated, assuming the non-disadvantaged disabled individuals are less likely to have problems, as the basic methodology logic. The preferences stated by the surveyed population are trusted and assumed true. Since the operability of the method is the core concern here, some exemplary results obtained are assumed to endorse the validity of the method.

In the second section, a brief literature review is provided about the current situation of the TD in general, with an emphasis on the disabled. Also, some previous preference-based works for transportation were exemplified. In the third section, the required data and its collection method by the household surveys, and the socio-demographic facts about the case area, Arao, are provided. The methodology comprises the fifth section, where both the preliminary cluster analysis in the definition of the TD, and the preference data analysis for the disabled are explained in steps. In the sixth section, the findings of the methodological approach are discussed. Finally, the general conclusions are drawn based on the findings.

II. Overview on the TD and the Disabled

The TD is defined as junction of various disadvantages that affect one's travel quality. The conceptualization of the TD can be found in the recent literature [5], [6], [7], [8], [9]. Authors conclude in consensus that continuous cut-backs from the public transportation services escalate the TD groups' inaccessibility [10], [9], [11]. For the Asian cities, the TD is especially linked strongly to poverty [1]. The steady growth in private car use and recent highway-based developments deteriorate the speed and safety of public and non-motorized modes by the congestion they create that the poor overwhelmingly use. Although poor people in these countries produce fewer trips than others, they are constrained to walking and bicycling even for longer trips. If they were given more opportunities and low-cost options, would they rather make more trips and choose other modes? Among the TD categories, the elderly and the disabled should be have a priority as the most vulnerable [12].

Travel demand models and the software have neglected to incorporate social considerations and the required participatory parameters for the TD, and disabled groups [13], [14], [15], [16]. The negligence of participation and consideration of the TD is probably due to their (especially the poor) powerless position [1]. As seen in some examples in the past, some actions "pretend-to-ask for participation" for justifying their insincere policies left only cynicism behind and were condemned by the poor and the disabled. As Barter emphasized [1], "Political processes and public participation must occur hand-in-hand with technical planning procedures". Stressing the coordination issue, understanding the role of active participation in policy-making for the TD groups is a must before any study or application should be encouraged by local authorities. Otherwise, "the consequences of poor system design remain borne by the excluded and (..) unvoiced." [16]. Participation can be possible in four ways: active participation to decision-making, public hearings, information-gleaning type participation (info-participation), and, labor type participation [17].

A clear definition of needs can help ensure that the solutions that are developed will be effective. Recalling the elements of success for effective solutions for the TD in society is the most recent one [3]. Special infrastructure (technology equipped special services) aiding especially the disabled and elderly groups that may bring additional cost. Thus, the funding issue would be the biggest obstacle for local authorities in taking effective steps, and may cause them refrain from taking these steps [2], [16], [18]. Choosing appropriate policies and technology can be cost-effective in helping those vulnerable groups only after their travel demands, preferences, modes and paths are well known in the first place [19], [20], [9], whereas "it is crucial for those who are dependent on a service and tend to know their way around it in some detail" [16]. Thus, finer information gathering from the impacted groups has a significant role as what reaction they would put against a set of policy choices. A noteworthy study attempted to model disabled groups' travel demands for paratransit services [21]. The finding of the previous study [5] of the modeling scheme for the TD that it has overall a lower trip generation rate than the normal population can be a motive for policy-makers to begin with; how should this finding be interpreted and treated then?

Many countries, however, (e.g., Sweden, Canada, Japan and Australia) have already launched legislation requiring improvements in transportation services such that all members of society have access and mobile equity [22]. Transport services in the U.S. for those who are considered to be the TD are: (1) ADA-complimentary paratransit for disabled people, (2) Medical purpose, (3) Job access, (4) services for seniors, (5) human services programs, (6) student transportation MAG agency is a successful one in such a coordination. Americans with Disabilities Act (ADA) in 1990 and the Act of Barrier-Free Design in Japan have especially contributed to the mobility of the disabled [2]. Some affordable public transportation applications in major Asian cities (as Manila, Seoul, Hong Kong and Singapore) have been successful for the poor, whereas little success has been gained in Bangkok, Jakarta, Delhi, and Hanoi [1].

Disabled persons are the most fragile group among the TD in general, not on the basis of their bodily impairment but of the infrastructure and services less adequately provided for them, and due to the hostile urban environment in excess of their movement capabilities when traveling. Hence, they should not be assigned categorically the disadvantaged *per se* for their handicapped conditions. Yet, within the context of the study, both truly disadvantaged disabled and the disabled who are non-disadvantaged will be the concern. Disability can appear in four basic dimensions as: (1) sensual disability (hearing, visual, etc.), (2) physical disability, (3) cognitive and mental disability, (4) health and frail related disability [4]. The last is usually accompanied with being old, and related diseases, etc. Any improvement effort should address all types of disabilities. Another category is defined interestingly as "being unable to accessible links", which may be the most relevant to the accessibility condition of a disabled person. In general, "elderly and disabled people travel less often than do abled people, even when work and business trips are omitted" [4]. In using transit services, those facts are tilting for Canadian case;

> "The greatest problems for users of local public transit are getting on/off the vehicle (52% of those who have difficulties using transit), standing in the vehicle while it is moving (49%) and getting to/locating the stop (33%)".. (which are solvable problems by systems quality design). "Seeing signs or notices is a problem for 20% of those transit users, obtaining information on routes or times for 17% and hearing announcements for 13%, which in fact could be solved by ITS equipment." 32% of transit users find waiting at the stop difficult.. (which could be reduced by demand responsive paratransit services or ITS) to provide information to the target users about when the service will arrive at the stop" .

In case of driving car, "enhanced vision, route guidance and emergency alert should improve safety and increase mobility".. There is also potential for using ITS to assist pedestrian disabled and elderly, particularly those with visual impairments. The planning policies should be adaptive to the special needs and preferences of various disabilities. In a carefully designed preference survey, disabled persons may suitably reveal what they need.

To equate the disabled to normal person's mobility level, more facility investment may be required in addition to special transit applications such as technology equipped paratransit services. Improvement of their travel conditions would mean additional cost burden over the local government budgets. To save from unnecessary spending, local governments and policy-makers should target best working policy areas with the prediction of consequences. Besides learning the target policies, learning also of the probable impacts of those policy measures would be beneficiary, to be ready for the aspects of travel demand that would be met in case the policies are to be deployed. Defining the most effective policies will both satisfy the travel need of the disabled properly, and satisfy cost-effectiveness criterion of policy application.

The travel demand modeling structure for the TD onto which our study approach partly bases had already been prescribed in the previous study largely. To summarize here, such modeling structure basically comprises three subsequent stages: (1) Data collection and analysis stage, where especially the necessary model inputs (variables) are described and the data process for readying for the cluster analysis procedure is explained. (2) Sequential 4-step modeling stage, where the normal population and disadvantaged population are modeled and the model parameters are calibrated for the base-year. (3) Equalization process, where, the TD's travel conditions are to be equalized to those of non-disadvantaged analyzing the differences between the normal model outputs and the TD's through various simulation trials. The basic layout of the modeling for the TD, of which the detailed results can be found in [5] is given in Fig 1. Within the context of the current study, only the 1st and 2nd stages of the modeling process are copied in data evaluation of the case study, Arao,

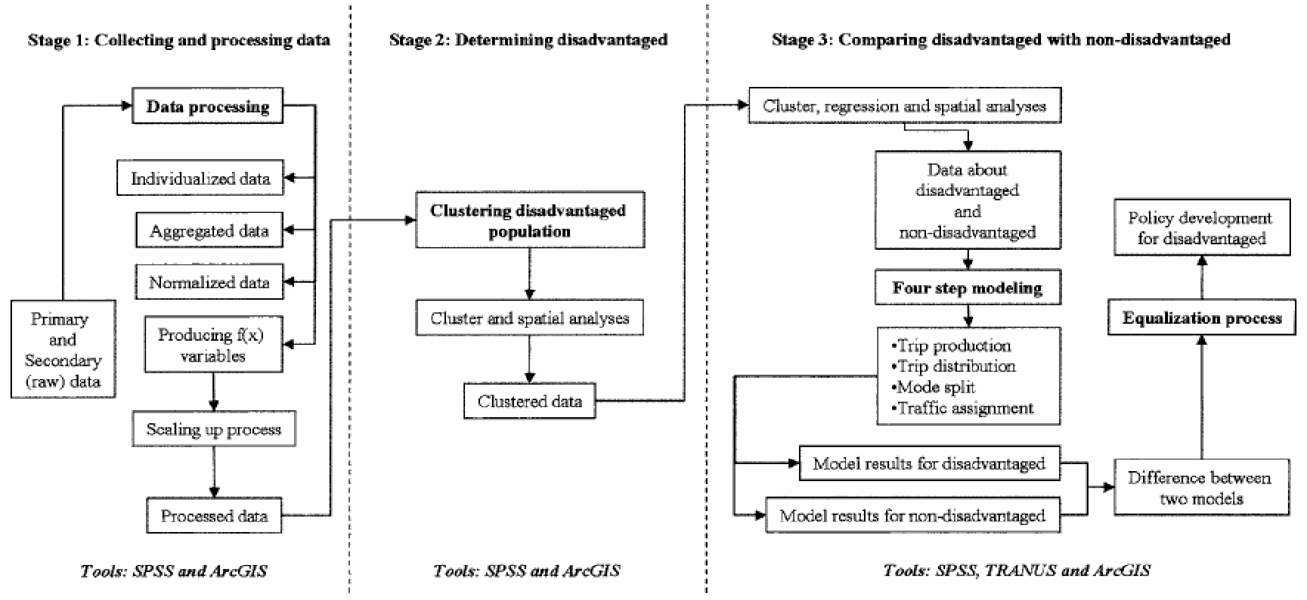


Fig 1. Flowchart of the Travel Demand Model for the TD (Source: Duvarci and Yigitcanlar, 2007)

which is the cluster analysis of the data.

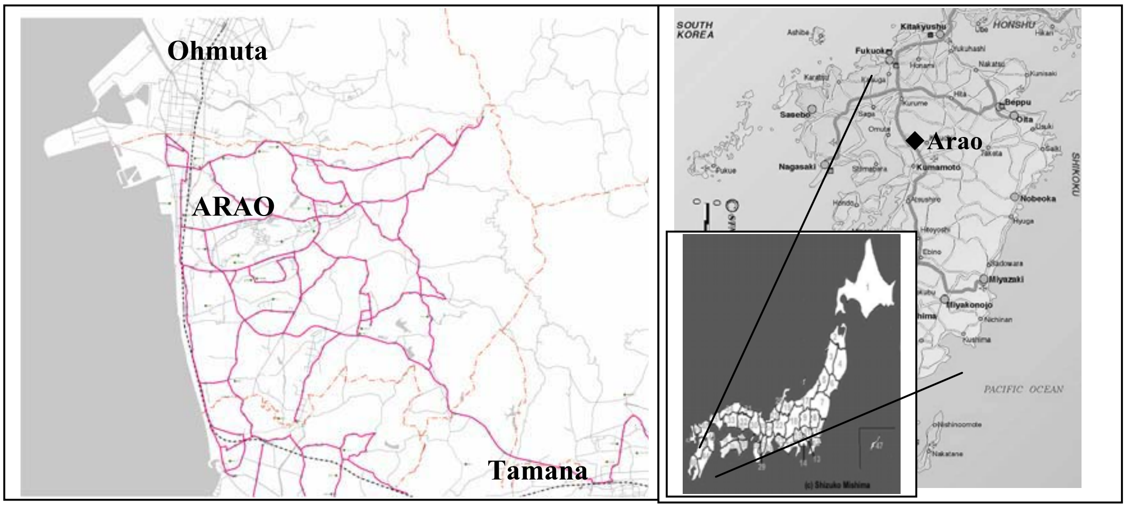


Fig. 2. Case city Arao and the road network with its location in the Kyushu Island.

III. DATA

The case town of Arao, is chosen for its high rate of elderly and disabled, dispersed settlement structure and car-based transportation that may further cause barrier effect to those TD. It has a population of 56,822 with the density of 9.9 person/ha. It is located in the northwestern corner of Kumamoto Prefecture by the Ishaya Bay about 30 km from the city of Kumamoto (Fig. 2). The county is between the counties of Ohmuta (of Fukuoka Prefecture) and Tamana. Average household size is 2.16. The elderly population above 65 years old is 36.4% from the surveyed population, which is greater than the 31.3% of the National Statistics. According to the survey statistics, combined with the high ratio of elder population, the rate of disabled is around %15, which is high, too. Unemployment rate is quite higher than other Japanese towns: 9.1% of the working age population (according to the National Statistics). Household survey sampling ratio is %2,7 in average.

The survey data of 663 households in Arao city were processed and 627 of them could be evaluated. 1342 (16 individuals were omitted due to non-response to none of the questions asked) individuals were observed, making an average of 89.5 observations per zone. The summary travel habits are shown in Table I. As can be noticed, the share of transit use is small. Non-replied questions meant no complaint about the current travel conditions, and assumed as high utility "response", whereas the non-response to all questions and those of handicapped individuals, are not omitted from the data, because their values are assumed the most dissatisfied.

The data were aggregated by fifteen zones and three trip purposes. Major trip purposes used in this study are 'work' (composed of commuting and business trips), 'others' (all other social, recreational, and health related trips), and 'return' trips (all home returning trips). Basic information about the characteristics of these zones and the transport facilities is gathered mostly from the local government (Table II). Household surveys conducted are based on the stratified random sampling method by zones and provided travel-making characteristics (Table III).

TABLE I
TRAVEL CHARACTERISTICS OF ARAO TOWN AND THE CURRENT TRANSPORTATION (AVERAGES)

Trip rate by purp	**Trip rate by modes***	**Modal shares**	**Trip length** & cost (average)**	**No. of transit lines**	**Gen. traffic sit. & problems**
work: 0.67 others: 0.73 return: 0.69 total: 2.13	walkbi: 0.25 private: 1.61 public: 0.13	walkbi: %13 private: %81 public: %7	wrk:12.1 282¥ oth:10.5 217¥ rtrn:11 276¥	23 inner 5 or 6 external	few peak hour congestions in central locations

* unknown mode trips are excluded, ** as kilometer

TABLE II
DATA SOURCES FOR THE STUDY

Travel demand charac's	Arao Person Trip Survey (APTS - 2007)
Road network	Digital map (Geographical Survey Institute, Japan) (2007)
Link capa's, network attr's	Local Government Planning Bureau (2007)
Pop. & socio-demo charact's	National Census (2004), and APTS

The disadvantage measuring variables used in the definition of the TD, which are identical with the if-condition policy proposals used in the preference analysis are labeled as follows; accessibility (a - 'Access'), physical barriers (b - 'PhysBarr'), land use and environmental conditions(c - 'LU'), system satisfaction and bus-stop conditions (d - 'TrSysQual'), and travel quality and comfort, (e - 'TravQual'). Accessibility to transport facilities is represented under the variable 'TrSysQual'. TravQual measures personal daily travel quality whereas TrSysQual is the evaluation about the transportation systems used or available for use. PhysBarr is about the various barriers while travel. Accessibility can have an indirect effect on income increases due to migration of jobs to suburbs [23], whereas another study found that land use factors such as location, accessibility, density, and mixed land use have no significant effect on trip rates [4]. The major variables were composed of minor variables, but the minors were not concerned in detail within the scope of the study. Also, the present paper work does not concern the details of how the disadvantages are measured using these variables, which was reserved to another paper study elsewhere. Here, only the cluster analysis outcomes used in the modeling of that paperwork were used as inputs exogenously.

TABLE III
HOUSEHOLD SURVEY RESULTS

zones	name	Population	responses	Sampl. ratio	disabled (%)
1	Yotsuyama	5,577	98	0.018	18 (%18)
2	Manda	4,948	86	0.017	12 (%14)
3	Ide	5,184	172	0.033	31 (%18)
4	Hirayama	2,357	60	0.025	6 (%10)
5	Kunai	2,930	123	0.042	21 (%17)
6	Arao	7,217	101	0.014	9 (%9)
7	Midorigaoka	896	65	0.072	6 (%9)
8	Masunaga	5,407	103	0.019	17 (%16)
9	Kawanobori	4,846	69	0.014	16 (%23)
10	Sakurayama	3,032	46	0.015	8 (%17)
11	Hatimandai	3,084	45	0.015	10 (%22)
12	Ariake	3,399	116	0.034	22 (%19)
13	Kiyosato	2,965	82	0.028	4 (%5)
14	Hatiman	3,538	142	0.040	15 (%11)
15	Fumoto	1,525	33	0.022	5 (%15)
	TOTAL	**56,905**	**89.4 (ave.)**	**0.027(ave.)**	**200 (%15)**

As of the cluster center results (Table IV) for each trip purpose, 'work' and 'other' (social) trips gave meaningfully divided clusters along with the differences in cluster center results, high ones showing the advantaged, and low ones the disadvantaged. Cluster center results were used in the first step of the methodology. Since the 'return' trips did not yield clear results, they were omitted from the preference data evaluation. In both work and others trips, there is one "incompatible" value in each, shown as underlined values.

TABLE IV
CLUSTER CENTER RESULTS for 3 TRIP purposes by variables

	Cluster (work)		Cluster (other)		Cluster (return)	
	1	**2**	**1**	**2**	**1**	**2**
Access	0.47	0.86	0.70	0.61	0.48	0.87
LU	0.43	0.74	0.60	0.55	0.44	0.76
TravQual	0.84	0.90	0.91	0.85	0.86	0.82
TrSysQual	<u>0.83</u>	0.62	0.66	<u>0.86</u>	0.88	0.59
PhysBarr	0.57	0.85	0.95	0.34	0.60	0.80

IV. METHODOLOGY OF PREFERENCE DATA EVALUATION

This paper devotes to the method of extracting the preference data out of the target groups, the disabled, thus, the full explanation of the steps of doing this will be given here. Since only the data of those disabled persons are concerned, here, the travel preferences of the disabled, but not those of elderly, are taken as the target group for two trip purposes, work/business trips and other (social/leisure/cultural) trips.

Stated preference (SP) analysis refers to the non-actual (or, hypothetical) attributes for choice, whereas Revealed preferences (RP) should be from among actual set of (limited) attributes for choice. Among our proposed policy options for choice, there is mixture of both actual and hypothetical (unreal) policy options. Preference indicators can be rank ordering, rating or choice in evaluating the best policy options for the target groups. On measuring the impacts of policy measures in a preference-based demand modeling, a Singapore-based study [25] developed a MS&R preference-based modeling of path choices of transit users for determining transit paths if the conditions of transportation (especially deploying ITS) are to be improved using questionnaire technique while people traveling. Another similar study investigated the value of time (VoT) perceptions for a variant price *en route* options [26].

The proposed preference evaluation method is quite original in the sense it aims to be representative of the mentioned 'information participation' of the disabled for the policy analysis stage, following simple logic rules but is restricted to single-time information across hypothetical policy measures (scenarios) (such as what an "increased accessibility" or "change in land use" means for the disabled). How would they be impacted from these changes? Utilizing MS&R preference survey techniques in order to understand travelers reactions against various policy (scenario) options can help the inclusion of the preferences of the users, enabling "participation" of the disabled to the decision-making, even if indirectly [26], [25].

The methodology is grossly made up of three components: (a) clustering approach utilizes zone-aggregated disadvantage index values for clustering, as copied from the modeling for the TD, (b) the Preference Data (called 'P.data') provides occurrence probability information of both policy preferred and trip impact expected the policies are determined as the input from the preference data of surveyed persons, and lastly (c) the policy-making stage aggregated from the household surveys against probable disadvantage conditions (same with the TD defining variables). As the first step, the observed population is clustered into advantaged and disadvantaged. Information from the "Preference Data", as of the clustering results of the TD, guides the choice of appropriate policy areas to focus.

In defining the general TD category, the statistical tool of cluster analysis is used to group similar observations into groups so that the members of the same groups are more similar than members of different groups or clusters [27], which has been widely used in transportation applications [28], [29]. The following assumptions are considered in this study during cluster analysis: the analysis to provide objectively defined outcomes; the analysis to divide the population on the basis of nearest neighbor rule; all variables and the value scales to have equal weights in the clustering process; all variable values to be scaled so the yield upward values representing the advantaged and the downward values the TD. Simple "*K* means" method of clustering in SPSS is applied without any subjective intervention. Each individual belonged to the cluster whose center is closest to that in terms of Euclidian distance [30].

After obtaining the clustered data of the TD population, the method simply follows the calculation of 'preference frequencies' (probabilities) of those disabled categorized as "disadvantaged". Yet, in the surveys, the respondents do not necessarily fill in the preference questions. The preference frequencies obtained at zone level are later summed up. The proportion of disabled in zones is used for zonal significance finally for the policy decision assessment. The preference frequency distributions by policy/impact cells are shortly named here 'P.data' in a matrix form. The 'P.data' index is found for each impact type defined. The logic rules follow as: Each respondent is asked to tick one "yes" option from among the five impact options for each if-condition (policy) among. Each respondent is limited to have one vote option for choice-making for every policy. Total frequency distributions are scored as "zone probability" values. In the first step, the general TD group's preference rates are found. Then, the specific disabled group's preferences from among the TD group are calculated in comparison to the group's general rates (i.e., without the disadvantaged separation), of which the process is explained in detail later. Then, the rate of those disabled falling into the disadvantaged category is configured, and the level of presence of those disabled among the TD is measured, which is an important gauge in policy-making analyses to be taken into calculation in the methodology part of this paperwork. Finally, those policy/impact cells having a value greater than 10 are assumed significant. The whole evaluation process can be depicted in four basic stages with additional zonal significance as in the scheme in Fig 3.

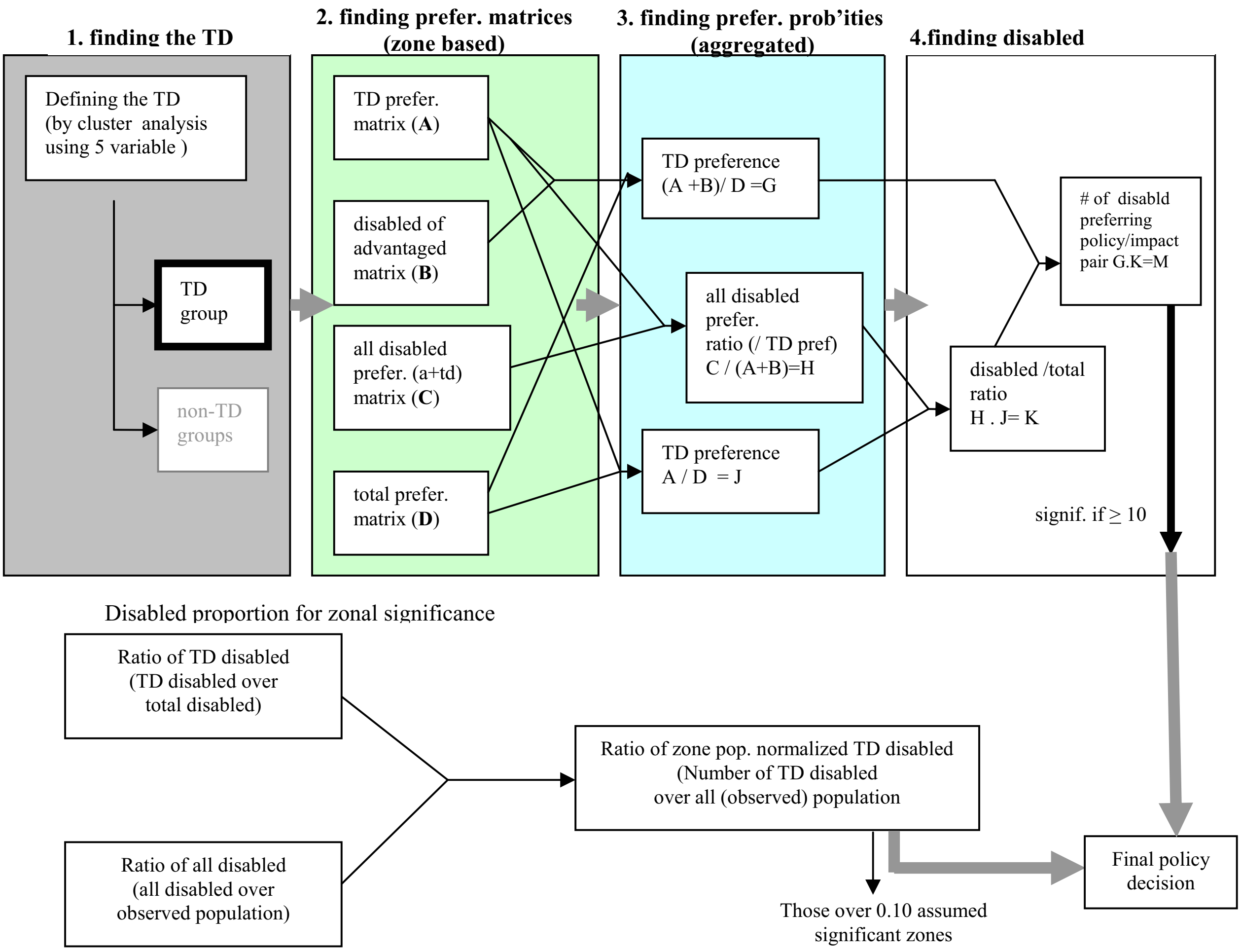


Fig 3. Process of revealing the policy-impact and zonal significances in helping the disabled.

A. Disadvantage Indexing

The 'TD variables' (policy areas) had been determined readily, thus, these values are introduced into cluster analysis stage exogenously beforehand, not being the scope of the current study, and the current work need not deal with finding of these disadvantage index values for each variable. The outcomes of the previous work are pursued, of which the cluster analysis results are given in Table IV.

Briefly, the 'disadvantage index' values are exported from another paperwork, which were to measure disadvantage levels in terms of five aforementioned major variables, in the end use as zone-aggregated values (arithmetic mean averages). After obtaining the disadvantage index values for each variable, the values become ready for the cluster analysis in defining of the TD. The initial cluster center results are presented in Table IV and used to decide which cluster could be assigned disadvantaged by variables and purposes. Clustering also provides the list of persons entitled to TD category. Only this TD data were regarded. For 'work' trips, the authors decided that the cluster 1 is the disadvantaged, however, for 'others' trips cluster 2 seemed to be the disadvantaged group. The 'return' trips produced totally obscure results, and were eliminated. For work trips, there are 699 persons entitled to the disadvantaged category out of 1341 (52% of all population) and for others trip, 633 persons (47%). That is, almost half the Arao people seems the TD. In the table, the TD clusters are grey toned. According to the cluster center results, the TD are not disadvantaged in terms of 'TrSysQual' variable for both 'work' and 'others' trip purposes. Thus, in the P.data evaluation and related simulation stage, this variable will be disregarded (omitted) in policy making.

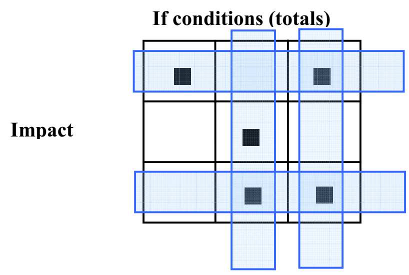
P.data values are gathered as the sum of "yes" (code 1 in the data) responses from the disabled persons out of the TD for the concern zone. Thus, a gauge is obtained to observe likelihood (probability) of policy impacts when the policy is supposed to be in effect for the disabled groups.

It is essential that the stated preferences mean the "probability" of the chosen policy is a preferred one among the target group. Thus, it is more likely to be a "successful" policy as far as the surveyed TD's responses are assumed trustworthy. By ticking "yes" for an option among the others, the respondent readily assumes his disadvantage linked to the condition (policy proposal) will totally be removed once this (and only this) condition is provided, but causing only the chosen impact on the system such as increased trip rate. Here, the policy proposal condition refers to an "improvement" in the policy. Not all people in the zone ticks "yes", some will tick other impact options, thus, choosing the option becomes a probability matter and a gauge for disadvantage improvement as well as the impact for if-policy cases.

B. Forming Stated and Revealed Preference Matrices

In the matrix of preference data, column headings represent hypothetical (stated) but probable policy proposals. The meanings of code names were provided before in the section, Data. In preference data matrices, they are similarly as follows: 'access' means: "if accessibility to major urban amenities could be maintained within 1 km distance", 'no barrier' (corresponding to the 'PhysBarr' variable) means: "if all the physical barriers are removed totally while traveling, and the infrastructure (including narrow streets) is improved", 'tr.syst.qual' means: "if the transit system quality (service, frequency, bus-stop conditions, reliability, etc.) is totally improved", 'landuse' ('LU' variable) means: "if the land use, design and planning is correctly done, or compensatory means such as community paratransit services in favor of the TD, disabled and elderly were provided", and finally 'travel qual' (originally 'Trav.Qual' variable) means: "if the in-vehicle traveling conditions (comfort, available seat, etc.) were ideal". All these variables can be assumed the stated preferences.

The rows, on the other hand, are the possible trip impacts (reactions), which are coded as:
Ra : trip rate impact "my trip number would double" (that is trip rate related impact),
Rb : trip cost impact "travel durations and/or costs would be less than half" (that is travel cost related impact),
Rc : modal shift impact "The mode I choose would rather be, walk/bike, public" (that is modal choice impact),
Rd : route choice impact "I would have more direct travels, or choose different routes I want" (that means transfers and is travel cost related impact),
Re : purpose shift impact "I would rather do trips for social and leisure purposes" (purpose shift)
The preferences from the data are distributed according to the above mentioned policy variable – trip impact pair matrix scheme (Fig. 4).



■show maximum values obtained, *'s show significant areas of interest (policy or impact).
Fig. 4. Cumulative impact evaluation on a sample policy-impact matrix

C. Configuring the General TD preferences

The variables (columns) and the 'trip impact's (rows) in the P.data matrix for each zone share the same preference rate values (probabilities) in measuring both the policy's weight for the TD and total trip impact. These probabilities are used later as the measure of significance (impact) for the policies, intended to address two questions: first, what type of impacts, and, second, how much impact they cause. The preference probabilities are zone aggregated values for measurability convenience. These zone-based values from respondents in zones are called "zonal preference" or "impact":

$$I_i^d = \sum_p y_p \qquad for \forall i \in Z \qquad (1)$$

$y = 1$, if y = "yes" (or, code 1) response exists for the TD respondents
where *I* represents the concern zone's impact value, i the counter of zone (Z), d the counter of the disadvantaged person in the zone, and p the number of persons surveyed.

D. Configuring Disabled Preferences as a Sub-category

The preference probabilities are calculated as zone-aggregated for convenience. That is, zones have the preference scores. Finally, they are aggregated in total for getting more robust results. The data of the disadvantage group of disabled and their relevant policy areas are determined for both trip purposes given the methodology steps in Table V as following;

TABLE V
STEPS OF DISABLED PREFERENCE CALCULATION OUT OF THE TD DATA

Steps	Explanation	process
1	Obtaining the total (sum of all zones) preference data matrix, y being the number of yes replies for the concern policy-impact matrix	$p^{pi}{}_d = \Sigma y^{pi}$ y: # of "yes" replies for the p-i pair policy area
2	Obtaining the matrix of general disadvantaged (d) ratio to total population (P) for each policy-impact combination (preference category) (d/P matrix)	$r^{pi}{}_d = d^{pi}/P$
3	Obtaining the matrix of those disabled (h) ratio to the total disadvantaged (h/d matrix) (here, we see the ratio of disabled among all disadvantage category for each policy-impact combination)	$r^{pid}{}_h = h/d$ h: being numb. of disabled
4	Following the disabled/disadvantage ratios, finding the existence probabilities of the disabled among all population multiplying the two matrices values above (steps 2 and 3)	$r^{piP}{}_h = r^{pi}{}_d . r^{pid}{}_h$
5	Multiplying the disadvantaged preference values (1st step) by the disabled ratios to population (4th step) (for final evaluation)	$P^{pi}{}_h = r^{piP}{}_h . p^{pi}{}_d$

In addition to the above steps, further zonal (or, geographical) significances can be determined by multiplying the zone's disabled population proportions by the final significance values, which will be presented in the Findings and Discussion section. The calculation is three-stage process to be executed for each zone: first, proportion of those surveyed disabled persons under the TD category in the zone who replied preference questions is determined, and then, the proportion of the total number of disabled to the surveyed population of the zone, and finally these two proportions are multiplied, to find combined probability of being both the TD and disabled together as shown below.

$$P_{disH}^j = H_{dis}^j / H^j \qquad (2)$$

where P^j_{disH} is Proportion of those disabled (H) under the TD category to the total number of disabled in the j^{th} zone. H^j_{dis} is the number of the disadvantaged disabled persons, and H^j is the total number of all (TD and advantaged) disabled persons surveyed in the zone.

$$P_H^j = H^j / T^j \qquad (3)$$

where P^j_H is the proportion of those disabled to the total number of surveyed population of the j^{th} zone. H^j is the number of all disabled person, as determined in the first step of calculation, and T^j is the total number of surveyed people in the zone.

$$I_{disH} = P_{disH} . P_H \qquad (4)$$

where I represents the policy significance index both in terms of disability and disadvantage significances . It is seen not necessary to show the j indices for zones.

V. FINDINGS AND DISCUSSION

The preference results would have been provided at zone level, if data level sufficed for significance. The aggregated results (i.e., total Arao town results), which presents more significant results than the individual zone-based result are provided for the work/business purpose trips and the 'others' (social/recreational, etc.) in the Tables 6 and 7 as of the results of the 1st step of the significance calculation process respectively below:

TABLE VI
TOTAL PREFERENCE SCORES OF THE DISABLED FOR WORK TRIPS (SIGNIFICANT ONES ARE BOLDED)

	POLICY OPTIONS				
IMPACTS (reactions)	**Access**	**no barrier**	**Tr.syst qual**	**Land use**	**Travel qual**
Trip rate	65	53	101	76	96
Time&cost	**169**	96	83	87	Na
Mode shift	**115**	82	**113**	97	Na
Route flex.	Na	**104**	89	79	Na
Purp. shift	92	72	100	68	84

TABLE VII
TOTAL PREFERENCE SCORES OF THE DISABLED FOR OTHER TRIPS (SIGNIFICANT ONES ARE BOLDED)

	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	59	54	85	61	**90**
Time&cost	**131**	87	69	73	Na
Mode shift	**90**	67	**100**	81	Na
Route flex.	Na	89	82	67	Na
Purp. shift	77	68	84	60	79

Tables 8 and 9 indicate the results for the disadvantaged/total population ratio matrices for two purposes respectively as of the results of 2nd step;

TABLE VIII
TD/ALL POPULATION PREFERENCE RATIO FOR WORK TRIPS

	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	0.60	0.57	0.67	0.65	0.63
Time&cost	0.7	**0.69**	**0.78**	**0.78**	Na
Mode shift	0.67	**0.7**	0.65	0.67	Na
Route flex.	Na	**0.71**	0.67	**0.76**	Na
Purp. shift	0.62	0.67	0.68	0.60	0.67

Where overall 'work' purpose disadvantaged ratio was found 0.52. Above this value are significant and bolded.

TABLE IX
TD/ALL POPULATION PREFERENCE RATIO FOR OTHER TRIPS

	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	0.53	**0.60**	0.56	0.52	**0.61**
Time&cost	0.54	**0.58**	0.55	0.54	Na
Mode shift	0.53	0.56	**0.59**	0.56	Na
Route flex.	Na	**0.61**	**0.63**	**0.59**	Na
Purp. shift	0.51	**0.64**	0.56	0.55	**0.61**

Where overall 'others' disadvantaged ratio was found 0.47

Below are the results (Table X and XI) for the disabled/disadvantaged ratio matrices for two purposes respectively as of the results of 3rd step;

TABLE X
DISABLED/TD PREFERENCE RATIO FOR WORK TRIPS (BOLD FIGURES ARE SIGNIFICANT)

	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	**0.23**	**0.26**	0.21	0.16	**0.24**
Time&cost	0.12	0.18	0.19	0.18	NA
Mode shift	0.17	0.20	0.17	0.13	NA
Route flex.	NA	0.18	0.17	0.14	NA
Purp. shift	**0.27**	**0.24**	0.22	**0.25**	0.21

TABLE XI
DISABLED/TD PREFERENCE RATIO FOR OTHER TRIPS (BOLD FIGURES ARE SIGNIFICANT)

	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	0.25	**0.26**	0.25	0.20	**0.26**
Time&cost	0.16	0.21	0.23	0.22	NA
Mode shift	0.21	0.24	0.19	0.16	NA
Route flex.	NA	0.21	0.18	0.16	NA
Purp. shift	**0.32**	0.25	**0.26**	**0.28**	0.23

Below are the tables (12 and 13) for the disabled/population ratio matrices for two purposes respectively as of the results of 4th step;

TABLE XII
DISABLED/ALL POPULATION PREFERENCE RATIO FOR WORK TRIPS (BOLD FIGURES ARE SIGNIFICANT)

	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	0.14	**0.15**	0.14	0.10	**0.15**
Time&cost	0.09	0.12	**0.15**	**0.14**	Na
Mode shift	0.12	0.14	0.11	0.09	Na
Route flex.	Na	0.13	0.11	0.11	Na
Purp. shift	**0.17**	**0.16**	**0.15**	**0.15**	**0.14**

TABLE XIII
DISABLED/ALL POPULATION PREFERENCE RATIO FOR OTHER TRIPS (BOLD FIGURES ARE SIGNIFICANT)

	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	0.13	**0.15**	0.14	0.10	**0.16**
Time&cost	0.09	0.12	0.13	0.12	Na
Mode shift	0.11	0.13	0.11	0.09	Na
Route flex.	Na	0.13	0.12	0.10	Na
Purp. shift	**0.16**	**0.16**	**0.15**	**0.16**	0.14

The final evaluation tables (14 and 15) for determining the disabled specific policy areas (i.e., determining the number of disabled people who prefer the option) for two purposes respectively as of the results of 5th step, which provides the clue about the most relevant policies and their possible impacts relatively:

TABLE XIV
NUMBER OF TD DISABLED PREFERRING POLICY/IMPACT OPTION FOR WORK TRIPS
POLICY OPTIONS

IMPACTS (reactions)	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	9.03	7.93	**14.00**	7.82	**14.53**
Time&cost	**14.70**	11.80	12.54	12.55	Na
Mode shift	13.50	11.20	12.31	8.67	Na
Route flex.	Na	13.55	10.00	8.39	Na
Purp. shift	**15.53**	11.39	**14.89**	10.27	12.05

TABLE XV
NUMBER OF TD DISABLED PREFERRING POLICY/IMPACT OPTION FOR OTHER TRIPS
POLICY OPTIONS

IMPACTS (reactions)	access	no barrier	Tr.syst qual	Land use	Travel qual
Trip rate	7.96	8.37	11.72	6.28	**14.01**
Time&cost	11.32	10.48	8.84	8.59	Na
Mode shift	10.05	9.02	11.23	7.32	Na
Route flex.	Na	11.65	9.44	6.46	Na
Purp. shift	**12.69**	10.93	**12.41**	9.39	11.04

When the final aggregated results were evaluated from the Table XIV and XV above, the forthcoming policy areas and the associated impacts expected (as the outcome of the surveyed disabled persons revealed opinions) can be read clearly, though other policy/impact cells seem non-negligible, where actually the table exhibits order of significance, which we must regard. Accordingly, for the work purpose trips, these policy/impact cells came affront (regarding the points above 14); TrSystQual and TravQual policies with trip rate increasing impacts (with 28.53 point). Access policy with time and cost reducing impacts (14.7 point). Again access and TrSystQual policies with purpose shift (30.42 point)(from private to public, or walk/bi modes) impacts. Note that 'Access' (with 30.23 points) and 'TrSystQual' (28.89 point) policies comes affront. For the other (social) trips; TravQual policy with trip increasing impact (14.01 point), and, Access and TrSystQual policies having the same purpose shift impacts (25.01 point). Simply, the planners should regard these revealed consequences when one or more of the mentioned core policies are to be considered.

For geographical significance of the results, as the last step of the method, also the disability significance levels were integrated as presented in the Table XVI below. These zonal findings simply mean that those marked** (significant) zones (9 and 11 for both trip purposes) have remarkably the highest disabled proportions in the zone together with the highest rates belonging to the disadvantaged category (also depicted on Fig 5) showing the concentration of the persons who are both disabled and the disadvantaged. Such consideration together with the determined policy-impact pairs which will guide the decision-maker in narrowing down:

TABLE XVI
ZONAL SINGIFICANCES AS THE DISABLED PROPORTIONS TO FOCUS BY TRIP PURPOSES

zones	work trips	Other trips	Notes and significance ("*" if ≥ 0.1, "**" if both)
1	**0.122**	0.092	* other (social) trips are close to serious disadvantage,too
2	0.046	0.07	
3	**0.112**	0.093	* other (social) trips are close to serious disadvantage,too
4	0.05	0.083	
5	0.065	**0.106**	* little unrest in social trips, but lowest among other zones
6	0.02	0.02	This zone has lowest disadvantage ratios for disability
7	0.031	0.031	
8	0.039	**0.126**	* social trips are quite problem compared to work trips
9	**0.116**	**0.159**	** quite a lot problems in both work & social trips
10	0.087	**0.109**	*
11	**0.178**	**0.17**	** the highest disadvantages ratios in both trips
12	0.069	0.095	
13	0.049	0.024	Quite low disadvantage results
14	0.035	0.077	
15	**0.151**	0.091	* work trips are quite problem, but social trips are also

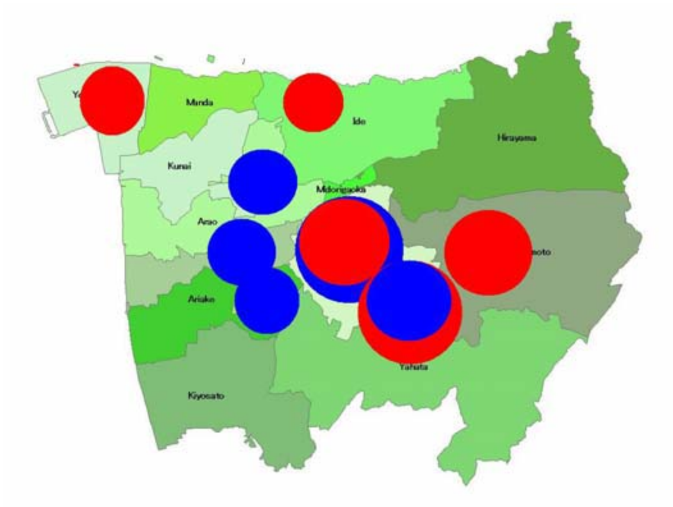


Fig. 5. disadvantaged-disabled-dense zones for both trip purposes in Arao, red circles representing work trips, blue circles representing social trips (*labelled significant zones in Table XVI were regarded)

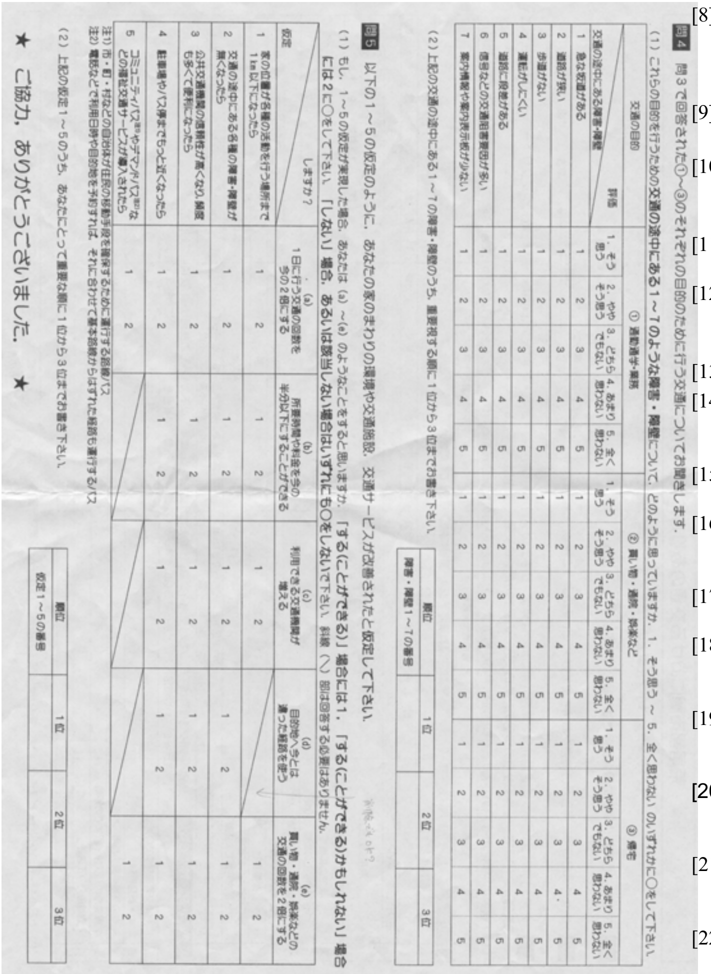
VI. CONCLUSION

As the purpose of this study is to show how the proposed novel approach can help decision-maker to have more refined results in focusing the most relevant policy options and the probable impacts of these options as well, before the application of policy measures, the current study produced some exemplary results. That is, the study put an experimental effort. Here, developing an MS&R preference-based modeling (perhaps later) is not concerned, and so is not the reliability of the results, but the initial trial of operability of the method. Developing such a method for supporting the decision-making addresses the recent "elements of success" concern to meet cost-effectiveness criteria.

By this approach, it is expected that the study took an important milestone in obtaining direct participation of those TD to the decision-making through information acquisition from them so as to be used in policy-making and simulation stages.

APPENDIX

Household Interview Form as the Japanese version:
Personal Travel Conditions and Preferences Survey Form
(Fourth page of four-page survey questionnaire)



ACKNOWLEDGMENT

We thank to the planning bureau staff in the Arao city local government for all their helping in gathering the necessary data about Arao, and its transportation systems.

REFERENCES

[1] R. P. Barter , "Transport and Urban Poverty in Asia: A Brief Introduction to the Key Issues", *UNCHS (Habitat) Regional Symposium on Urban Poverty in Asia*, Fukuoka, 27-29 October , 1998.

[2] J. Fitzgerald, D. Shaunesey, S. Stern, "The effect of education programs on paratransit demand of people with disabilities", *Transportation Research Part A*, Vol. 34, pp. 261-285, 2000.

[3] Transit Cooperative Research Program (TCRP). "Strategies to Increase Coordination of Transportation Services for the Transportation Disadvantaged", Transportation Research Board of National Academies, Rep. No. 105, Washington D.C., 2004.

[4] C. G. B. Mitchell, "Intelligent Transportation Systems (ITS) Applications for Improving Transportation for Elderly and Disabled Travellers", (Report TP 12925E) Transportation Development Centre, January, 1997.

[5] Y. Duvarci and T. Yigitcanlar, "Integrated modeling approach for the transportation disadvantaged." *J. of Urban Planning and Development*, Vol. 133, N. 3, pp.188-200, 2007.

[6] J. Hine and F. Mitchell, *Transport Disadvantage and Social Exclusion*, Ashgate, 2003.

[7] J. Hine and M. Grieco, "Scatters and clusters in time and space: implications for delivering integrated and inclusive transport." *Transport Journal*, Vol. 10, pp. 299-306, 2003.

[8] F. Pennycook, R. Barrington-Crags, D. Smith, and S. Bullock, Environmental Justice: Mapping Transport and Social Exclusion in Bradford, Friends of the Earth, 2001. Available: http://www.foe.co.uk/resource/reports/env_justice_bradford.pdf

[9] A. Church, M. Frost, and K. Sullivan, "Transport and social exclusion in London." *Transport Policy*, Vol. 7, N.3, July, pp.195-205, 2000.

[10] Social Exclusion Unit Making the Connections: Final Report on Transport and Social Exclusion, Office of the Deputy Prime Minister, 2003. Available: http://www.socialexclusionunit.gov.uk

[11] A. Gilbert, "Bus Rapid Transit: Is Transmilenio a Miracle Cure?", *Transport Reviews*, Vol. 28, N.4, pp. 439 – 467, 2008.

[12] K. Lucas, "Providing transport for social inclusion within framework for environmental justice in UK." *Transportation Research: Part A*, Vol. 40, pp. 801-809, 2006.

[13] D. Banister, *Transport Planning*. London: E & FN Spon, 2002.

[14] J. Dodson, B. Gleeson, and N. Sipe, "Transport disadvantage and social status: A review of literature and methods" (Report). Urban Policy Program, Griffith Univ., Dec., 2004.

[15] White Paper. The Future of Transport: A Network for 2030 (Report by Department for Transport) July, London, 2004.

[16] M. S. Grieco, "Transport and social exclusion: New policy grounds, new policy options." *10th International Conference on Travel Behaviour Research*, Lucerne, August, 2003.

[17] E. B. Sharp, *Urban Politics and Administration*, New York: Longman, 1990.

[18] P. L. Mokhtarian, I. Salomon, and S. L. Handy, "The impacts of ICT on leisure activities and travel: A conceptual exploration" *Transportation*, Vol. 33, pp.263–289, 2006.

[19] Y. Duvarcı and S. Mizokami, "What if the suppressed travel demands of the transport disadvantaged were released: Results of simulation approach", *Journal of EASTS*, Vol. 7. pp. 1433-1445, 2007.

[20] C. Nicolle and B. Peters, "Elderly and Disabled Travellers: Intelligent Transportation Systems Designed for the Third Millenium", *Transportation Human Factors*, Vol. 1, N.2, pp.121-134, 1999.

[21] P. Bearse, S. Gurmu, C. Rapaport, and S. Stern, "Paratransit demand of disabled people", *Transportation Research Part B*, Vol.38, pp. 809–831, 2004.

[22] S. L. Suen, and C. G. B. Mitchell, *Accessible Transportation and Mobility: Transport in the New Millennium*, Washington D.C., 2000.

[23] G. L. Thompson, "New insights into the value of transit: modeling inferences from Dade County" *Transportation Research Record* 1753, no. 01-2229, pp. 52-58, 2001.

[24] R. Ewing, M. DeAnna, and S. Li, "Land use impacts on trip generation rates." *Transportation Research Record* 1518, pp. 1-6, 1996.

[25] S. Lam, and F. Xie, "Transit path-choice models that use revealed preference and stated preference data" *Transportation Research Board* 1799, no. 02-3052, pp. 58-65, 2002.

[26] Y. Alver, and S. Mizokami "A combined RP/SP route choice study between expressways and ordinary roads by using route choice survey's data" *JSCE Infrastructure Planning Review*, Vol. 23, N.2, pp. 521-532, 2006.

[27] B. Ripley, *Pattern recognition and neural networks*, Cambridge: Cambridge University Press, U.K., 1999.

[28] T. Hauser, W. Scherer, and B. Smith, "Signal system data mining." *Studies*, Charlottesville, Va: University of Virginia Press, 2000.

[29] J. Smith and M. Saito, "Creating land-use scenarios by cluster analysis for regional land-use and transportation sketch planning", *J. Transp. Stat.*, Vol. 4, N.1, pp. 39–51, 2001.

[30] B. Everitt, *Cluster analysis*, London: Oxford University Press, 1993.