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BENEFIT INCIDENCE ANALYSIS OF MITIGATION BANKING SYSTEM ON ROAD PROJECT

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Abstract: Most of studies on Mitigation Banking System (MBS) which is the mechanism to compensate the environment destroyed by development in the U.S. mainly focus on its advantages, limitations and administrative viewpoints, although its remarkable futures is the application of market mechanism. Few studies discuss the economic impacts on each stakeholder in the market mechanism. This paper aims to investigate such impacts on five agents in a road project: government, mitigation banker, landowner, resident, and private firm. With five developed individual economic models and the benefit incidence table, it was found the cost to conserve environment was shared by whole society because the road organization allocated the tax revenues from each agent to the budget of compensatory mitigation. The perception on the MBS benefit and cost flows through a marketing mechanism is useful not only for Japan, but also for any places planning to implement MBS for protecting their environments.

Key Words: Mitigation, Mitigation Bank, General Equilibrium Theory

1. INTRODUCTION

Mitigation concept has been introduced in the U.S. by enacting National Environmental Policy Act (NEPA) in 1969. This mitigation concept means to consider by the priority of order of avoidance, minimization and compensation of its impact on nature environment by carrying out development projects such as a road project. Under the NEPA Act, development projects must be justified whether Environmental Impact Assessment (EIA) and mitigation plan should be applied or not. In addition, revised Clean Water Act (section 404) in 1972 enforces developers to provide a mitigation plan as a required component of EIA process (Isobe 1997, Mary 1996, Furota et al 2001). The mitigation plan includes the compensatory mitigation plan that is the final measure to create, restore and/or enhance the nature environment in order to keep the standardized environmental capacity. Developers must pay these compensatory mitigation costs for development projects destroying natural environment. However, based on the U.S. experiences, carrying out compensatory mitigation by developers themselves causes many problems such as risk of expenses, failure of environmental creation, dispersion of ecosystem, etc. (Tanaka 2000). For solving these problems, many states such as Minnesota State, Florida State and Wisconsin State have established the Mitigation Banking System (MBS). The MBS refers to a system in which the restoration, creation, enhancement, or preservation of nature environments is recognized by a regulatory agency as generating credits that may be used to compensate for multiple environmental impacts through a marketing mechanism. The MBS that is an innovation system to trade nature environment has not been established in other countries besides U.S.A.

The MBS mostly has been applied for conserving wetlands from various development projects, such as highway and port constructions, residential area developments, etc., in many states of U.S. They have shown that the MBS can offer the potential for restoration and conservation of ecological and natural environments. This has stimulated a number of planners in Japan considers to introduce the MBS to protect the nature environments have been severely damaged by infrastructure developments for years. This article is an effort to determine the applicability of MBS implementation in Japan. Definitely, the feasibility to utilize the MBS can be evaluated in many points of view, such as political, economical, and technical aspects, etc. Before effectively implementing such MBS measures in Japan, it is vital to evaluate in all aspects. In the political and technical viewpoints, the authors found that the MBS has a potential to be utilized for conserving the natures, because it is necessary to request developers to efficiently compensate the damages of environmental systems in the future. Particularly to introduce the MBS into Japan, the conservation target must be clearly stated in the law. This helps to effectively protect the natures from the chronic environmental degradations (Ito and Fukuda 2003, Ito et al 2003). This paper aims to study the economic and marketing mechanisms of MBS. The evaluation issues of other aspects are out of scope in this article.

Even though, many studies of MBS have been carried out on the advantages and some limitations, very few have focused on its economic impacts. The economic impacts are very important to be considered, as they have the influences to drive the marketing mechanism of MBS. They also affect to the accomplishment of MBS on trading credits among involved parties, and on forming budgets to conserve the nature environments. On the other words, they significantly control the benefit and cost flows in the system (Morimoto 2000, Isobe 1999, Tanaka 1999, Connie 1999). Based on developing benefit incidence table, the study scope of this paper is to determine the marketing mechanism of MBS for a road project from the economic point of view. To do so, the economic models of each stakeholder or related party must be developed and analyzed to identify the flows of benefit and cost. The study can be divided into three parts: basic concept of mitigation banking system, development of economic models, and analysis of benefit incidences. These parts are explained in the next sections.

2. BASIC CONCEPT OF MITIGATION BANKING SYSTEM

In order to understand the economic impacts generated by the MBS marketing mechanism, it is essential to know the basic MBS components, especially for mitigation bank and compensation credits. Normally, mitigation bank is defined as a system in which the creation, enhancement, restoration, or preservation of nature environments is recognized by a regulatory agency as generating compensation credits allowing the future development of other conservative sites. For the compensation credit, it is the unit of nature environment value that is recognized as the basis for comparing the destroyed natures to the banked natures offered in compensation (Paul and Robert 1996). For example, in the case of wetland conservation, credits may be expressed in units such as acres, habitat units, or numbers. In addition, it can be considered that the common MBS deals with five agents, including government, mitigation banker, landowner, resident, and private firm.

For mitigation banker, it is classified into two types, consisting of public and private bankers. In private banker, it is also possible to be divided into two groups: they are private firm and household. These agents and compensation credits form a market mechanism of MBS in

conserving the nature environment by considering credit as commodity with valuation of nature environments. A general marketing mechanism is a system that a private sector functions as a mitigation banker, as demonstrated in Figure 1. This study also considers this market formulation as a basis of economic impact study because the system that mitigation banker is a private sector has influences to significantly drive a marketing mechanism. This can represent the real interactions among agents. However, for this preliminary study of economic impacts, it focuses on the case of household banker, since its uncomplicated conditions. Certainly, more complicated situation, such private firm banker, many bankers in the system, etc., must be taken into account for the further studies so that the complete understanding on MBS can be provided.

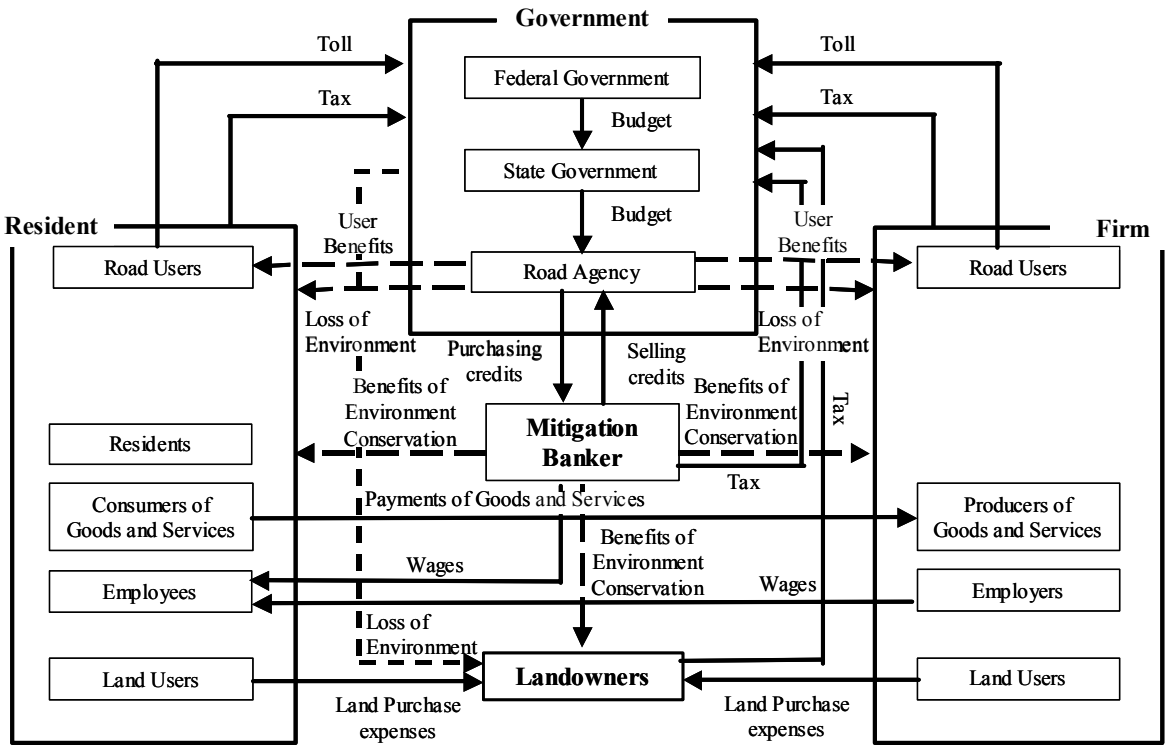

Figure 1. Relationship of Mitigation Banking System

In Figure 1, it can be seen that each agent has an important role in the system. The agent trading the credits is called mitigation banker. Mitigation banker gets the credits by acquiring land and increasing the amount of nature environment through creating and/or restoring, and then saves it as credits. While mitigation bankers generally rent or buy land services from landowners, they can earn some profits from selling their credits to a road or transportation agency (Okada 2001, Ito 2003). Moreover, a mitigation banker probably affects to various stakeholders, such as resident, landowner, government etc., through the benefits of environmental conservation. A government collects taxes from resident, mitigation banker, landowner and private firm, and spends them for road construction and environmental protection. A landowner profits by selling and leasing land to private firm, mitigation banker and resident. Definitely, both private firm and resident are able to get the benefits from the accessibility improvements of road projects and the environmental conservation.

The level of environmental consideration is provided the minimum requirements by environmental policies and laws, however it depends on how developers propose their mitigation plans after all. Road agency that is one of developers tries to maximize the social

benefit within the budget constraint. Thus, road agency attempts to minimize the costs for conducting compensatory mitigation. However, suggested mitigation plan must satisfy the conservation level that can be obtained the permission to develop. Government plays a role to check the mitigation plans drafted by developers whether those plans were examined environmental consideration carefully or not, and grants the permission to develop to developers.

The risk of MBS occurs especially in case of managing mitigation bank by private firm. In general, private mitigation bankers search a place for mitigation bank site where they expected to be carried out compensatory mitigation near the area in the future. Thus, if the area of compensation was smaller than estimated area, the credits will be unsold. Thus, there is a possibility that they may not be able to make a profit. In case of managing mitigation bank by public organizations such as DOT, they estimate necessary compensatory area for future developments and produce credits. The common risk between private and public mitigation bank is to fail creating and/or restoring environment for producing credits.

The involved economic models can represent this mechanism in term of the general equilibrium theory. The economic models representing the behaviors of each agent can evaluate the flows of costs and benefits generated by introducing MBS. The outcomes of these models can be obviously analyzed by exploiting a benefit incidence table, as illustrated in Table 1. The table can points out the important matters as follows.

- The fairness of benefits and costs can be examined.
- The items not considered through market mechanism, such as taxes etc, can be determined for the better understanding.
- The social net benefit can be estimated by the summation of subtotal for each benefit item in the right corner.

Table 1. The Semiotic Benefit Incidence Table

Agents	Government Sector		Mitigation Bank Sector			Private firm Sector				Resident Sector				Landowner Sector	Total
Items	Road Agency	Government	Producers of Credits	Land Users	Road Users	Producers of Goods and Services	Employers	Land Users	Road Users	Residents	Consumers of Goods and Services	Employees	Land Users	Landowners	
Road Budget	+	−													0
Cost of Road Construction	−														−
Maintenance Cost	−														−
Credits	−		+												0
Cost for Producing credits			−												−
User Benefits					+				+						+
Toll	+				−				−						0
Loss of Environment										−				−	−
Benefit of Environment Conservation										+				+	+
Price of Goods and Services						+					−				0
Wages							−					+			0
Land Rent				−				−					−	+	0
Taxes		+		−		−						−		−	0
Total	0	0	+	−	+	+	−	−	+	0	−	+	−	+	SNB

Furthermore, the perception on the economic impacts caused by the mechanism on each agent aids to clarify the impacts of introducing MBS in Japan. In particular, it can describe that how a marketing mechanism is generated, how it affects to every stakeholder, and how the MBS helps to conserve the nature environments, etc. Most MBS studies in Japan recommended that the MBS should be implemented, but they have never explained that how the budget of MBS implementation can be formulated, and what is the important role of each agent, especially who should pay for the conservation costs. Therefore, it can be seen that determining MBS

from the economic aspect or marketing mechanism provides the valuable knowledge of MBS application. This is not only for local practices in Japan, but also in any places that want to effectively conserve their natures.

3. DEVELOPMENT OF ECONOMIC MODELS

This section aims to develop the economic models based on general equilibrium theory and the benefit incidence table in order to analyze the flow of benefits and costs for considering the mitigation banking system. The economic models constructed in this study have been relied on the existing researches, especially the study of Takagi (2002) and Morisugi (1997). The development process can be classified into 4 parts, including the assumptions of social economic model developments, the economical behaviors of each involved party, the establishment of economic models, and the market equilibrium, respectively.

3.1 Assumptions of Social Economic Model Developments

To develop social economic models, some assumptions are necessary to be arisen in this study. The assumption can be described as follows.

- The society is divided into the zoning system occupying uniform spaces.
- Land uses in a zone must be carefully considered. They are dedicated for residence, business, and mitigation bank site.
- The society consists of household sector, private firm sector, absentee landowner sector, government sector and mitigation banker sector considered as the stakeholders in this study.
- Department of Transportation (DOT) is included in the government sector. Moreover, the government purchases credits from a mitigation banker for the future road projects.
- The markets of the society form for land market, labor market, synthetic good market, and credit market.
- When a household, private firm, and mitigation banker need to utilize land services, they can rent from landowner.
- The marketing mechanism in the society is a long-term equilibrium condition.

3.2 Economical Behavior on Each Party

This study considers five main stakeholders consisting of household, private firm, mitigation banker, landowner, and government. The economical behavior on each party must be considered under the following assumptions.

- The household behavior is based on the utility maximization under time and income constraints. The behavior of location choice is supposed to be considered by the probability of random utility theory. In addition, the study also assumes that each household has only one employee.
- The behavior of private firm is relied on the profit maximization under land area and production technical constraints.
- The landowner behaves all actions based on land supply under land area constraints.
- The government collects the taxes from all sectors in the society. Particularly, on behalf of the government, DOT is the one who takes a responsibility to carry out road projects.
- The mitigation banker's behavior is based on the profit maximization under land area and production technical constraints.

3.3 Establishment of Economic Models

To develop the economic models, the specific models of each party must be considered in detail. This study develops five models for five parties, including household, private firm, mitigation banker, landowner, and government. Each model has to be developed separately. The detail of each model is explained in the following sections.

3.3.1 Economic Model of Household

The household behavior of residential location choice decides a premises area and its amount of demand under the condition that household selects the place of residence. The location utility of household can be represented by land service (a_{jh}), leisure time (s_{jh}), environment service (x_{jh}) and synthetic good (z_{jh}). While environment service (x_{jh}) is the consumption level that is provided by implementing road project, ε, shows its quality such as a residence environment. l_{jh} represents the labor time. The utility function of the household is not including l_{jh}, because it is reported that the value of time is equal to the wage time (Morisugi 1995) and the later formulation can be expanded easily. c_{jh} is the commuting transport time. The household maximizes the utility by a_{jh}, l_{jh}, s_{jh}, x_{jh} and z_{jh} under the time and income budget constraints. It is supposed that zone h is the place where a private firm utilizes, and zone j is the place of residence. Thus the household behavior model is shown as follows.

$$\max_{a_{jh},\ s_{jh},\ l_{jh},\ x_{jh},\ z_{jh}} \quad U_{jh}\left[a_{jh},\ s_{jh},\ x_{jh},\ z_{jh};\ \varepsilon_j\right] \tag{1}$$

$$\text{s.t.} \quad s_{jh} + l_{jh} + tx_{jh} + c_{jh} = T, \tag{2}$$

$$r_j a_{jh} + px_{jh} + p_z z_{jh} = w_h l_{jh} + y + y' + g \tag{3}$$

where p: Travel cost to location given service
p_z: Price of synthetic good
T: Total available time
W_h: Wage rate in zone h
y: Allotment of profit from private firm
y': Allotment of land rent absentee landowner
h: Zone where private firm utilizes
j: Zone where is the place of residence

Eq.(2) and (3) are the time and income constraints, respectively. The demand function a_{jh}, s_{jh}, x_{jh}, z_{jh} and supply function l_{jh} can be showed by calculating from Eq.(1) to (3),

$$a_{jh} = a_{jh}\left[p_z,\ q_h,\ r_j,\ \Omega_h;\ \varepsilon_j\right] \tag{4}$$

$$l_{jh} = l_{jh}\left[p_z,\ q_h,\ r_j,\ \Omega_h;\ \varepsilon_j\right] \tag{5}$$

$$s_{jh} = s_{jh}\left[p_z,\ q_h,\ r_j,\ \Omega_h;\ \varepsilon_j\right] \tag{6}$$

$$x_{jh} = x_{jh}\left[p_z,\ q_h,\ r_j,\ \Omega_h;\ \varepsilon_j\right] \tag{7}$$

$$z_{jh} = z_{jh}\left[p_z,\ q_h,\ r_j,\ \Omega_h;\ \varepsilon_j\right] \tag{8}$$

$$q_h = p + w_h t \tag{9}$$

$$\Omega_h = w_h T + y + y' + g \tag{10}$$

$$v_{jh} = v_{jh}\left[p_z, q_h, r_j, \Omega_h; \varepsilon_j\right] \tag{11}$$

q_h is generalized travel cost, and Ω_h is generalized disposable income. If equations from (4) to (8) are substituted for (1), indirect utility function V_{ij} can be calculated.

$$v_{jh} = v_{jh}\left[p_z, q_h, r_j, \Omega_h; \varepsilon_j\right] \tag{12}$$

A household chooses the residential place based on location utility.
It is supposed that the location utility of household has random variables following Gumbel distribution, the choice probability of resident location can be acquired by logit model.

$$P_{jh} = \frac{\exp[\omega V_{jh}]}{\sum_k \exp[\omega V_{kh}]} \tag{13}$$

$$N_{jh} = P_{j,h} N_h \tag{14}$$

where: P_{jh}: Probability that private firm locates in zone h
N_{jh}: The number of commuters from resident zone
N_h: The number of employees in zone h
ω: Dispersion parameter of error term

3.3.2 Economic Model of Private Firm

The behavior of private firm in choosing business location normally can be divided into two phases as well as for the household. At first, it has to consider the phase to decide premises area and its amount of demand under the condition that private firm selecting the location. And then, a private firm controls the demand level of land service (A_h) and labor (L_h), and synthetic good (Z_h) of supply level, and maximizes the profit on business location.

$$\max_{A_h,\ L_h,\ Z_h} \quad p_z Z_h - (R_h A_h + w_h L_h + G) \tag{15}$$

$$\text{s.t} \quad Z_h = Z_h[A_h, L_h] \tag{16}$$

where: p_z: Price of synthetic good
Z_h: Supply level of synthetic good
R_h: Business location rented in zone h
A_h: Demand level of land services
w_h: Wage rate
L_h: Demand level of labor
G: Imposed one lump tax

The demand functions (A_h and L_h), and the supply function (Z_h) can be calculated from Eq. (14) and (15).

$$A_h = A_h[p_z, \quad R_h, \quad W_h, \quad G] \tag{17}$$

$$L_h = L_h[p_z, \quad R_h, \quad W_h, \quad G] \tag{18}$$

$$Z_h = Z_h[p_z, \quad R_h, \quad W_h, \quad G] \tag{19}$$

The profit function Π_h can be calculated by substituting (16) and (18) for (14).

$$\Pi_h = \Pi_h[p_z, R_h, w_h, G] \tag{20}$$

This profit is distributed among households. At the second phase, it is supposed that private firm selects a business location by following a maximum profit. It is supposed that the profit of private firm levels on alternatives have random variables, which are independently and identically distributed with Gumbel distribution. The choice probability is presented by logit model.

$$P_h = \frac{\exp[\Pi_k]}{\sum_k \exp[\Pi_k]} \tag{21}$$

$$M_h = P_h M \tag{22}$$

where: P_h: Probability that private firm locates in zone h
M_h: The number of firms
M: Total number of firms
θ : Dispersion parameter of error term

3.3.4 Economic Model of Mitigation Banker

Mitigation banker controls demand (K_m) of land service and supply (C_m) level of credit. And then it produces credits and maximizes profits by selling credits. It is assumed that mitigation banker doesn't create any employment. This is referred to the case study of Minnesota State (Ito 2003). The behavior of mitigation banker tries to maximize the profit by selling credits and minimizes the cost for producing credits. Thus, the utility function is shown as follows.

$$\max_{C_m,\ K_m} \quad p_c C_m - (R_m K_m + R_m E + G_m) \tag{23}$$

where: p_c: Price of credit
C_m: Supply level of credit
R_m: Land rent of mitigation bank site
K_m: Demand level of land service
E: Cost for creating credit
G_m: Imposed one lump tax

Supply function of C_m and demand function of K_m are as follows.

$$C_m = C_m\ [p_c, R_m, E, G_m] \tag{24}$$

$$K_m = K_m\ [p_c, R_m, E, G_m] \tag{25}$$

Thus, profit function can be presented by Eq. (24) and (25).
It is supposed that mitigation banker selects a bank site with the following profit maximization in each zone of their business area. The profit function is composed of pc, Rm, E and Gm as follows.

$$\prod_m = \prod_m [p_c, \ R_m, \ E, \ G_m] \tag{26}$$

$$P_m = \frac{\exp\left[\nu \prod_m\right]}{\sum_k \exp\left[\nu \prod_k\right]} \tag{27}$$

$$O_h = P_m M \tag{28}$$

where: P_m: Probability that mitigation banker locates in zone h
O_h: The number of mitigation bankers in zone h
M: Total number of mitigation bankers
ν : Dispersion parameter of error term

3.3.3 Economic Model of Landowner

Landowner is defined as the household that has land but doesn't live in there, and the behavior of landowner should be formulated as the household mentioned before. It is supposed that an absentee landowner exists in a zone, and supplies the place of resident (k_i) to household, the lands for private firm and mitigation banker (K_i, K_m).

$$k_i = \sum_h a_{ih} N_{ih} \tag{29}$$

$$K_i = A_i M_i \tag{30}$$

$$K_{im} = A_m O_i \tag{31}$$

where: a_{ih}: Land service to households
N_{ih}: The number of households
k_i: The area of residence that can be supplied in zone i
M_i: The number of private companies
K_i: The area of business that can be supplied in zone i
A_m: Land service to mitigation bankers
O_i: The number of mitigation bankers
K_{im}: The area of mitigation bank that can be supplied in zone i

Πa is total profits of landowner from land rent of resident, private firm and mitigation bank site, and the tax to government is subtracted.

$$\prod a = \sum_i r_i k_i + \sum_i R_i K_i + \sum_i R_m K_m - \sum_i g' \tag{32}$$

where: r: Land rent of resident
R: Land rent of private firm
R_m: Land rent of mitigation bank site
g': Imposed one lump tax

3.3.4 Economic Model of Government

It is supposed that the government invests in road projects from investment (I) that is funded by taxes from households, private firms, landowners and mitigation bankers. And it is considered for the budget to purchase credits from mitigation bankers. Thus, investment I is represented by subtracting the cost for purchasing credits from the sum of each tax revenue as follows.

$$I = \sum_j \sum_h gN_{jh} + \sum_h GM_h + \sum_h G_m O_h + \sum_h g' - p_c C_f \tag{33}$$

$$g = \alpha G = \beta G_m \tag{34}$$

where: I: Investment to road project

: $\sum_j \sum_h gN_{jh}$: Tax from households

$\sum_h GM_h$: Tax from private firms

$\sum_h G_m O_h$: Tax from mitigation bankers

:C_f: The amount of credits that should be saved for the future road projects

α, β. γ: Parameters that represents the ratio of tax burden on each agent

3.4 Market Equilibrium

Social economic model is constructed on basis of multi-regional general equilibrium theory. The market equilibrium condition is considered under the profit allocation conditions of private firm and landowner, tax income and expenditure condition of the government. This includes 4 market equilibrium conditions, consisting of land market, labor market, synthetic market, and credit market. The price of synthetic is assumed 1.

Resident: $k_i = \sum_i a_{jh} N_{jh} \quad (i = 1,2,3,\ldots,n)$ (35)

Business location: $K_i = A_i M_i \quad (i = 1,2,3,\ldots,n)$ (36)

Mitigation bank site: $K_m = A_m O_i \quad (i = 1,2,3,\ldots,n)$ (37)

Labor: $L_h M_h = \sum_j l_{jh} N_{jh}$ (38)

Synthetic good: $p_z \sum_h Z_h M_h = p_z \sum_j \sum_h z_{jh} N_{jh} + I$ (39)

Credit: $p_c \sum_h C_m O_h = p_c C_f$ (40)

Profit of private firm: $\sum_k \prod_h M_h = y \sum_j \sum_h N_{jh}$ (41)

Profit of landowner: $\sum_i r_i k_i + \sum_i R_i K_i + \sum_i R_m K_m - \sum_i g' = y' \sum_j \sum_h N_{jh}$ (42)

Profit of mitigation banker: $\sum_h \prod_m O_h = Y \sum_h O_h$ (43)

where: Y: Allotment of mitigation banker

$$\text{Tax}: I = \sum_j \sum_h gN_{jh} + \sum_h GM_h + \sum_h G_m O_h + \sum_h g' - p_c C_f \tag{44}$$

$$g = \alpha G = \beta G_m \tag{45}$$

4. ANALYSIS OF FLOW OF BENEFIT ON MITIGATION BANKING SYSTEM

In this paper, the economic models of MBS were developed to grasp the impacts on each agent group concerning a road project. Conducting a road project will change not only the environmental quality but also the price of land services, the wage of rate and so on, which depend on the market equilibrium. The net benefit is defined the increase in the household's utility level that evaluated in monetary terms, which is calculated by using the concept of equivalent variation (EV).

4.1 The Household's Net Benefit

The household's net benefit is assumed that it can be defined by using the concept of the expectation value of maximum utility level based on the random utility theory. and the benefit is derived from comparing between with and without the project. The expectation value of the maximum utility level is called the satisfaction function. The satisfaction function that represents the maximum expectations utility level of household in zone h is shown as follows (Morisugi 1991).

$$S_h[V] = \frac{1}{\omega} \text{In} \sum_i \exp[\omega V_{jh}] \tag{46}$$

where: V: Vector of indirect utility function V_{jh}

Eq.(12) is substituted for (46).

$$S_h[V] = S_h[1, q_h, r, \Omega_h; \varepsilon] \tag{47}$$

where: r: Vector of land rent for resident
ε: Vector of environment quality level

The satisfaction $S_h[V]$ means that the utility level can be represented by the expectation value of the maximum utility. Thus, the residential relocation benefit of the household is the net benefit EV_h by a road project, which is defined as the value of EV satisfying the following equation.

$$S_h[V^b] = S_h[1, q_h^a, r^a, \Omega_h^a + EV_h, ; \varepsilon^a] \tag{48}$$

Eq.(48) is defined the minimum compensation amount that is necessary to give up the change of utility by conducting a road project under the condition that maintains the expectation utility with project, and it can be transformed as follows (Morisugi 1995).

$$EV_h = \oint_{a \to b} \sum_j P_{j,h} \left(-x_{jh}\, d\, q_h - a_{jh}\, d\, r_j + l_{jh}\, d\, w_h + d\, y + d\, y' - d\, g + \Omega_\varepsilon\, d\, \varepsilon_j \right) \tag{49}$$

where: $\Omega_{\varepsilon} = \dfrac{\partial \Omega_h}{\partial \varepsilon_j}$ (50)

4.2 Social Net Benefit

The social benefit by carrying out road projects is the sum of the household's net benefit. Eq.(51) is called the incidence form of social net benefit because all the items in the equation are measured at the place where all the repercussion effects influence the households.

$$\begin{aligned} SNB &= \sum N_h EV_h \\ &= \sum \oint_{a \to b} \sum_j \sum_h N_{jh}\left(-x_{jh}\, d\, q_h - a_{jh}\, d\, r_j + l_{jh}\, d\, w_h + d\, y + d\, y' - d\, g + \Omega_{\varepsilon}\, d\, \varepsilon_j\right) \end{aligned} \tag{51}$$

4.3 Analysis of Benefit Incidence Matrix

For making benefit incidence matrix, Eq.(50) derives from applying the envelop theorem to Eq.(15) that is private firm's profit maximization formula, and substitutes its equation for market equilibrium condition.

$$\sum_h M_h d\Pi_h = \sum_h M_h\left(Z_h dp_z - A_h dR_h - L_h dw_h - dG\right) \tag{52}$$

Since p_z was assumed 1, dp_z is 0. Eq.(53) is derived from substituting the market equilibrium condition of labor and synthetic good for Eq.(52), and also insert dp_z=0 into (52).

$$\sum_h \sum_j N_{jh} dy + \sum_h \sum_j N_{jh} l_{jh} dw_h = -\sum_h M_h A_h dR_h - \sum_h M_h dG \tag{53}$$

The market equilibrium condition of profit of landowner and tax differentiate for inserting to Eq.(51).

$$\sum_j \sum_h N_{jh} dy' = \sum_i k_i dr_i + \sum_i K_i dR_i + \sum_i K_{mi} dR_{mi} - \sum_i dg' \tag{54}$$

$$dI = \sum_j \sum_h N_{ij} dg + \sum_h M_h dG + \sum_h O_h dG_m + \sum_i dg' - p_c C_f \tag{55}$$

By applying the envelop theorem to Eq.(23) that is mitigation banker's profit maximization formula, and substitutes its equation for market equilibrium condition of profit and credit..

$$dI = \sum_j \sum_h N_{ij} dg + \sum_h M_h dG + \sum_h O_h dG_m + \sum_i dg' - p_c C_f \tag{56}$$

By substituting the market equilibrium condition of the profit of mitigation banker and credit, Eq.(57) is given as.

$$dI = \sum_j \sum_h N_{ij} dg + \sum_h M_h dG + \sum_h O_h dG_m + \sum_i dg' - p_c C_f \tag{57}$$

By substituting Eq.(51) for Eq.(53-55) and Eq.(57), social net benefit is shown by Eq.(58) that composes all variables.

$$
\begin{aligned}
SNB = \sum \oint_{a\to b} \sum_i \Big(& \underbrace{\sum_h N_{ih}\Omega_\varepsilon d\varepsilon_i}_{<1>} - \underbrace{\sum_h N_{ih} x_{ih} dq_h}_{<2>} - \underbrace{\sum_h N_{ih} a_{ih} dr_i}_{<3>} - \underbrace{\sum_h N_{ih} dg}_{<4>} \\
& - \underbrace{M_i A_i dR_i}_{<5>} - \underbrace{M_i dG}_{<6>} + \underbrace{+k_i dr_i}_{<7>} + \underbrace{K_i dR_i}_{<8>} - \underbrace{dg'}_{<9>} + K_{mi} dR_{mi} \Big) \\
& - \underbrace{\sum_i O_i dG_m + C_m dp_c}_{<10>} - \underbrace{\sum_i O_i dY}_{<11>} - \sum_i O_i E dR_m \\
& + \underbrace{\sum_i \sum_h N_{ij} dg}_{<12>} + \underbrace{\sum_i M_i dG}_{<13>} + \underbrace{\sum_i O_i dG_m}_{<14>} + \sum_i dg' - dI - p_c C_f
\end{aligned}
\tag{58}
$$

The terms from <1> to <14> in Eq. (58) represent the benefits and the costs of household, private firm, landowner, mitigation banker and government respectively. These benefits and costs are shown in benefit incidence table (Table 2). The ripple effect of the benefit incidence in case of introduction of MBS to road projects can be analyzed by making benefit incidence table. The reason why sum of line of land, tax and credit becomes 0 is that the benefits and costs cancel out. Therefore, these impacts don't affect social impact including SNB in these economic models.

Table 2. Benefit Incidence Table

Agents / Items	Household	Private firm	Landowner	Mitigation Banker	Government	Total
Environment	<1>					Σ <1>
Transport	<2>					Σ <2>
Land	<3>	<5>	<7>	<9>		0
Tax	<4>	<6>	<8>	<10>	<12>	0
Investment					<13>	-I
Credit				<11>	<14>	0
Total	Σ (<1>+<2> +<3>+<4>)	Σ (<5>+<6>)	Σ (<7>+<8>)	Σ (<9>+<10> +<11>)	0	SNB

5. CONCLUSION

As mentioned about Mitigation Banking System (MBS), it is an effective measure in the mitigation concept. For long time, the MBS has been employed to conserve the nature environments from the land and infrastructure developments in U.S. In Japan, though a lot of natures have been damaged from development projects, especially for road constructions, the MBS implementation was recently discussed on its applicability in this country. However, most of existing researches investigated the MBS in political and technical aspects mainly, the study of MBS in the viewpoint of economic impacts and the marketing mechanism is very rare. Therefore, this study intended to study the economic impacts of MBS on five agents: government, mitigation banker, landowner, resident, and private firm, in the marketing mechanism. To do so, the economic models of each agent's behavior had to be developed and analyzed based on the general equilibrium theory. The benefit incidence table was inevitably developed to evidently analyze the benefit and cost flows. This helps to explain that how a marketing mechanism is generated, how it affects to every stakeholder, and how the MBS helps to conserve the nature environments, respectively.

As the results, the conclusions are as follows:

- The mitigation banker directly affects on the landowner and the government. The investment for carrying out road projects that was collected by levying taxes on each agent is deducted from the expenses to purchase credits. Thus, it seems the investment decreased.
- However, the investment may not decrease practically because the government levies the tax on the mitigation banker directly and the tax on the basis of profit by rent from mitigation banker on landowner indirectly.
- The profit of mitigation banker depends on the demand level that is decided politically.
- Essentially, the nature environment was conserved by the taxes form the household, the private firm, the landowner and the mitigation banker because the expenses to buy credits based on these taxes.

For the further study, the benefit incidence table of MBS developed in this study must be applied with the actual data collected from the field survey in order to check the accuracy of developed models and to understand agents' actual behaviors. Moreover, the evaluation of MBS implementation from multi-aspects, such as political, technical, and economic views, must be performed so that a comprehensive MBS plan can be provided.

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