Social Simulation with Logic Model of Mind Set
-Application on Farmer's Behavior to Protect Coral Reef-

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***ABSTRACT*:** The New Public Management is recently applied in national and local administration. However, there are a few examples of numerical simulations and models for policy evaluation of policy outcome. Policy evaluation method called "Social simulation" was examined in the case of social phenomena simulation and policy evaluation by using Logic model of Peoples' Mind Set and Multiple Agent Theory to protect coral leaf at Ishigaki Island. Farmers' mind in decision making was modeled as a logic model which was derived from the cognitive map model constructed by interviewing farmers. In this paper, one of the countermeasures to protect coral leaf is shown as intercropping pumpkin among sugarcane fields, and this policy will be examined whether farmers would accept or not. Multi-Agent Simulation (MAS) model for an evaluation the behavior of the sugarcane farmers was developed by using Logic model of Peoples' Mind Set, which was extracted from cognitive map model. It shows the whole factors and interconnecting them related to the peoples' responses to the countermeasures. The interaction among individuals was modeled with MAS as the Logic Model of Peoples' Mind Set. Each agent has different Logic Model responds to seven input parameters, such as the harvest risk of the disaster etc. In this case, decision making of execution of the pumpkin intercropping among sugarcane fields was modeled as a Mind Set. Pumpkin market price depends on the number of the pumpkin intercropping farmers, and it influence to the peoples' income which is also going to be the input of the Logic Model of Peoples' Mind Set. Iterative analysis of MAS gave us the simulated result of the past phenomena at Ishigaki Island, showed how people responded to the policy, and validity of MAS was investigated.

KEYWORDS: New Public Management, Social simulation, Multi Agent simulation Model, Logic Model of Peoples Mind Set, Policy evaluation method

1. INTRODUCTION

The New Public Management is recently applied in national and local administrative. As for these, it aims to fill the efficiency and orthodoxy of service and project, and the administrative management technique is being applied in all municipalities now. However, there are some cases that service and project cannot be efficiency and orthodoxy. In administrative management, it is the significance of existence to achieve the set policy objective from the policy aims. Multiple indices are set to accomplish the policy objective, and the target value of the index is decided. The administration executes the project by using own resource for the target value accomplish in the index. In the project evaluation, it is divided into ex-post evaluation to judge the project continuance after the project is executed of ex-ante evaluation to decide the project execution before the project is executed. An

ex-ante evaluation bears the project and a very important decision making is borne for the execution selection. However, it was clarified that neither efficiency nor legitimate of the project was necessarily secured in ex-ante evaluation of existing. In addition, the citizen's consideration might not be considered by the project execution judgment in citizens' action execution support project. It has aimed to propose the project evaluation method that considers a social simulation by The Logic model of Peoples' Mind Set for the decision making support in multiple business selections from which legitimate has been secured by the policy logic model to solve this. The coral reef deterioration and the extinction problem of Ishigaki Island were taken up in this research. The legitimate of the coral reef protection project was verified. Next, the multi agent simulation model that used the Logic model of Peoples' Mind Set was constructed. Finally, the phenomenon reproducibility of the simulation was verified.

2. Model used

2.1 Policy logic model

The policy logic model is a systematic administrative management system by a hierarchical input, output, and outcome of which policy is applied. Final output or outcome is the result of middle, initial output and baseline input, respectively. It is analyzed by using the problem recognition obtained from the questionnaire interview of a citizens group. Finally, the impacts and satisfaction from inputs or governmental policies will be evaluated.

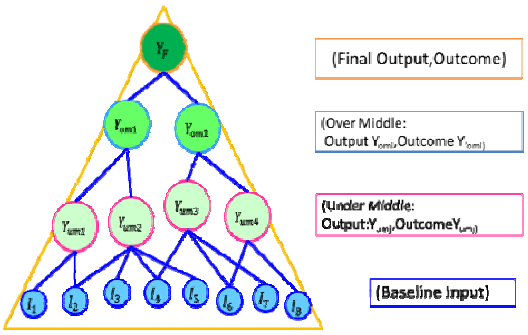


Figure 1-1 Outline chart of policy logic model

2.2 Social simulation

This section describes the outline of a social simulation in this paper. A social simulation concentrates in behavior of the individual that composes a certain society, and constructs the "MAS" model as artificial decision making based on an individual code of conduct. The project evaluation by the social simulation proposes with this paper has aimed at the decision making support to achieve the state at which specific of the factor to give a definite action to specific. The phenomenon of the society and society aim is a range of the possibility that the model calculated under a certain condition (set scenario) for the decision making support. A social simulation has aimed at the decision making support to achieve the state at which specific of the factor to give a definite action and the phenomenon of the society. It constructs the "MAS" model composed in artificial decision making model. "Agent" is based on an individual code of conduct. The project evaluation by the social simulation proposes is a range of the possibility that the model calculated under a certain condition (set scenario).

2.3 Outline of mas

MAS (Multi-Agent Simulation) is a technique for trying the presumption of the social phenomenon by a bottom-up approach. It is one of the techniques to practice a social simulation. MAS is a tool that can analyze the mechanism of the

phenomenon and factor by modeling the interaction between the behavior of the individual. That is the component of the society and the individual. It was treated originally in the intelligence machine field as game theory and the artificial intelligence field. However, there are also applications in the social science field such as land use and the traffic action simulation in the engineering and planning with the market forces in the economics field. It is a bottom-up approach that basically uses the concept of the agent models though the technique of a social simulation. Moreover, Artisoc of the structural plan laboratory Ltd. is used in this paper.

2.4 The Logic model of Peoples' Mind Set

The Logic model of Peoples' Mind Set is a hierarchical-structural chart of consideration concerning an individual action. The policy logic model clarifies how the business and the measure executed to improve a related index by hierarchizing the index relating to the target value achievement about the policy. In a related index, it is necessary to clarify what trouble you feel when and what it causes. The action is executed when the citizens' behavior relates to the achievement of the index. In constructing the Logic model of Peoples' Mind Set, Kato's problem technique and logic model technique have been used. If it is the citizen's action, the field of the object doesn't become the restraint factor of the technique.

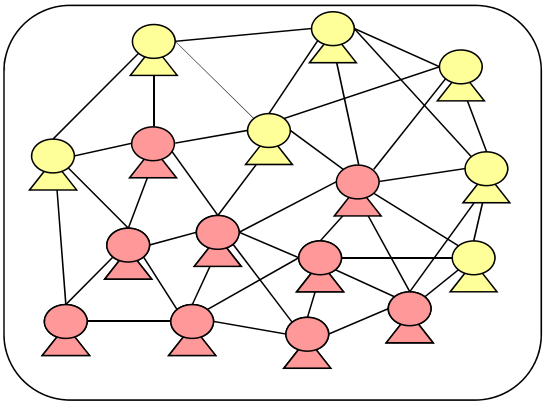


Figure 1-2 Network between individuals in MAS

2.4 The Logic model of Peoples' Mind Set

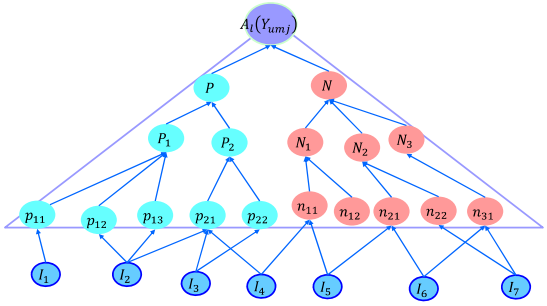


Figure 1-3 The Logic model of Peoples' Mind Set

3.1 Application to red clay outflow control action in Ishigaki Island.

In this section, a social simulation by the Logic model of Peoples' Mind Set is applied to the red clay outflow problem causing the coral reef deterioration and extinction in Ishigaki Island. First of all, the background of the coral reef deterioration and extinction in Ishigaki Island and the backgrounds of the problem like a red-clay-outflow problem are described. Next, the MAS model of the red-clay-outflow control of Ishigaki Island to this problem is constructed. Then, the construction of the sugarcane farmer agent concerning the red-clay-outflow control of the Ishigaki Island is constructed by using the Logic model of Peoples' Mind Set.

3.2 Coral reef deterioration and extinction problem in Ishigaki Island

There are the problem of coral reef extinction and deterioration in Ishigaki Island. The red clay outflow from the island is enumerated as the main factor of this problem. By this reason, the red-clay-outflow control measures should be carefully solved. Though the farmland is corrected the inclination as hard measures and the farmland is coated vegetation as soft measures have been done in the present time. However, the cost is still high and the farmer's

cooperation us still low. The value and protection cost of coral reef of the coral reef should be balanced. At the same time, social public welfares should become the maximum. However, even if a social public welfare becomes the maximum, it is difficult to approve when and who pay the cost but do not receive the actual profit because those the private enterprises and the individuals execute the coral reef protection business. The sugarcane farmer's cooperation is necessary to reduce the red-clay-outflow. However, if the agriculture product is not productive, the farmer will not execute the red-clay-outflow control. Then, there are farming measures as a technique for be attracting attention as a red-clay-outflow control means now. "Shimanosai intercropping cultivation" that is one of the farming measures that can control the red-clay-outflow by changing the sugarcane field to the intercropping cultivation of sugarcane and Shimanosai. Revenue growth by sales of different vegetables is the reason why this measure attracts attention. This is an incentive to the farmer. However, to achieve the suitable red- clay-outflow control and coral reef protection, the construction of the impact, the sugarcane farmer decision making system and the reaction of the citizens in this community is needed.

4.1 social simulations

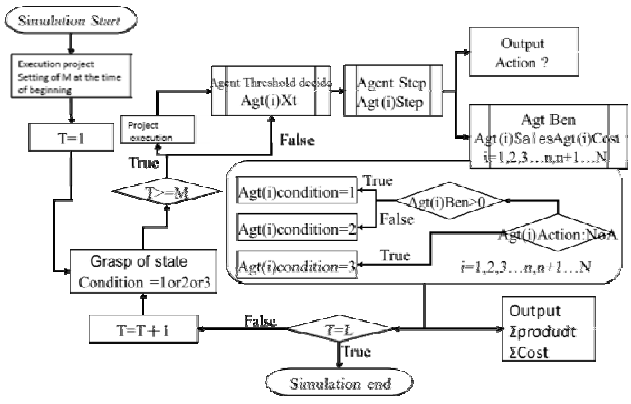


Figure4-1 MAS algorithm of sugarcane farmer group that examines intercropping cultivation execution

Each variable in red-clay-outflow control simulation by MAS model in the Ishigaki Island is described in this section especially, sugarcane farmer's pumpkin intercropping cultivation behavior. In the same time, the situation of the pumpkin intercropping cultivation are decided by the Logic model of Peoples' Mind Set in the space where the sugarcane farmer agent exists in the MAS model constructed by using Artisoc. Next, execution and the non-execution of the pumpkin intercropping cultivation of all sugarcane farmers are decided. Finally, the production of the intercropping pumpkin and market price are also calculated from an intercropping execution area of the sugarcane farmer with a technological coefficient.

4.2MAS algorithm of sugarcane farmer group that examines intercropping cultivation execution

The red-clay-outflow controlling effects of Ishigaki Island are derived by calculating the amount of the outflow from the pumpkin intercropping cultivation execution area. Moreover, agricultural revenue and expenditure is also executed by each intercropping cultivation execution area and the sugarcane production area. Each agent decides the success or failure of the pumpkin intercropping cultivation to the sugarcane farmer. All processes are assumed to be 1 step. It is assumed one year in 2 steps because of assumption that the pumpkin intercropping cultivation executes it twice in one year. In this paper, the observation period is 25 years or 50 steps. This is assumed to be one trial, and the iteration is 100 times. The efficiency and effect among two or more projects in this paper was calculated by using the MAS model. First, the simulation of the sugarcane farmer will be executed. After 16 steps, the project is executed from the trial beginning so that the MAS model should consider the phenomenon.

4.3agent model

The model construction and the setting of the environment surrounding the sugarcane farmer agent group are constructed. In this section, the sugarcane farmer agent who is the basis of the MAS model is described. First, the action process of sugarcane farmer is calculated in terms of where and whether the pumpkin intercropping cultivation is executed in each step. Next, execution judgment decision model by the consideration structure logic model and the threshold used for sugarcane farmer's interaction and decision making is illustrated.

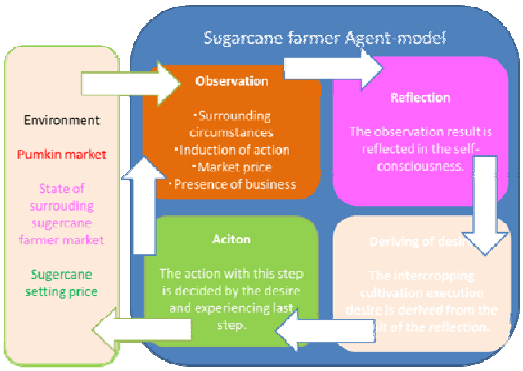


Figure4-2 sugarcane farmer Agent-model

4.4Sugarcane farmer agent action process among MAS models

The process of the decision of the execution selection for the pumpkin intercropping cultivation in sugarcane farmer's was shown in Figure 4-5. The algorithm was shown in Figure 4-6. Figure 4 and 5 shows the relationship between the outside environment and the selection action (pumpkin intercropping cultivation). The sugarcane farmer agent is an algorithm of the classification factor of each phase in the pumpkin intercropping cultivation execution selection process shown in Figure 4-6. The action process of the sugarcane farmer agent consists of the process of the observation, the reflection, the desire deriving, and the action selection.

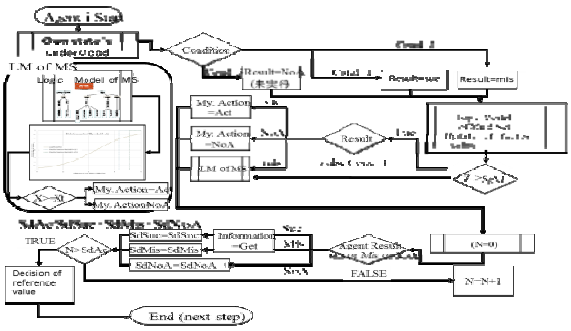


Figure4-3 Sugarcane farmer agent's pumpkin intercropping cultivation execution decision algorithm

4.5Pumpkin intercropping cultivation execution selection process of sugarcane farmer agent

The sugarcane farmer agent observes whether the project is executed by the administration and what result the selected action caused. Moreover, a surrounding sugarcane farmer agent observes the action result of front step by this phase, and it is reflected in the consideration factor of the Logic model of Peoples' Mind Set in the following phase. The setting of the parameter as the reference level of the pumpkin intercropping cultivation behavior of a surrounding sugarcane farmer agent is described in the next paragraph.

The sugarcane farmer agent derives the next pumpkin intercropping cultivation execution desire from the Logic model of Peoples' Mind Set from which surrounding circumstances are reflected to each other. The Logic model of Peoples' Mind Set is shown in Figure 4-7. The action is selected, and executed referring to the execution desire of the pumpkin intercropping cultivation calculated from the Logic model of Peoples' Mind Set. This is a series of process done with each step until setting step in the MAS model is completed.

4.6Sugarcane farmer agent's pumpkin intercropping cultivation execution decision algorithm

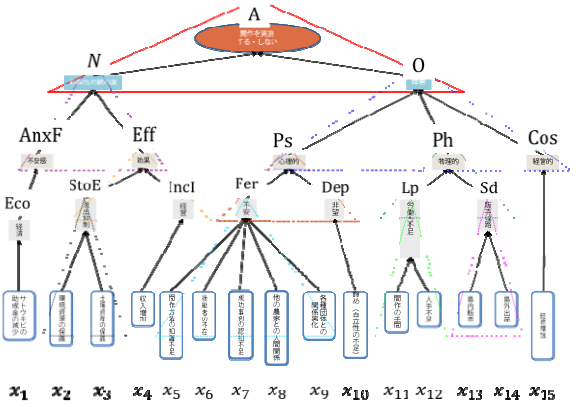


Figure5-1 The Logic model of Peoples' Mind Set in execution selection of pumpkin intercropping cultivation of sugarcane farmer

5.1The Logic model of Peoples' Mind Set in execution selection of pumpkin intercropping cultivation of sugarcane farmer

When the execution of the pumpkin intercropping cultivation is examined, the sugarcane farmer agent in MAS models uses the Logic model of Peoples' Mind Set concerning the execution of the pumpkin intercropping cultivation. The execution desire in the pumpkin intercropping cultivation can be calculated by making this model into each block as a function. At this time, the value of each factor is calculated by a multiple regression analysis as used in the research of past the Logic model of Peoples' Mind Set. The distribution function of each block is used and calculated by using the idea of the kernel multivariate analysis. On the other hand, assumption of the factor that influenced a superordinate factor was only a subordinate factor for there were two kinds or more of composition factors and the title factor were set. The coefficient of the subordinate position factor is calculated from a multiple regression analysis of the answer in the questionnaire survey after each distribution function of the subordinate factor is used and calculated. The questionnaire survey data concerning the sugarcane farmer's pumpkin intercropping cultivation execution was surveyed in October, 2009.

5.2Block □ necessity and trouble → execution desire

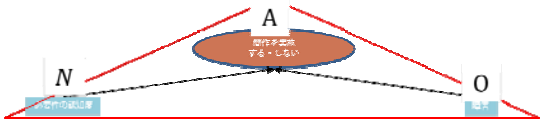


Figure5.1 Block1Execution desire of pumpkin intercropping cultivation that consists of necessity and trouble

The execution desire of the pumpkin intercropping cultivation of block □ is described in this section. The execution desire of the pumpkin intercropping cultivation is composed when the necessity and the pumpkin intercropping cultivation becomes a cause. It is assumed the probability distribution in the MAS model, and the superordinate factor value is calculated from the value in agent's each factor. The result and the logical adjustment in which the execution desire factor value is high appeared by the recognition of the necessity and there was neither trouble nor feeling when consideration concerning distribution was described. At this time, the execution desire of the pumpkin intercropping cultivation is assumed to be no existence of the composition factors other than the necessity factor and the trouble factor.

The function of the execution desire assumed as the subordinate position factor was constructed by using a multi-regression analysis. Each sugarcane farmer agent calculates the execution desire of the pumpkin intercropping cultivation by using this function. In the following paragraph, each sugarcane farmer agent describes the process where the execution selection of the pumpkin intercropping cultivation is.

$$A_i = 0.59A_i(N_i) + 0.33A_i(O_i) \quad (R^2 = 0.87) \text{EQ(5.1)}$$

$$\varphi\left(A_i(N_i)\right) = \sum_{n=1}^{5} \gamma_{Nn} \left(exp(-0.5(A_i(N_i) - n)^2)\right) \text{EQ(5.2)}$$

$\varphi(A_i(O_i)) = \sum_{n=1}^{5} \gamma_{On} \left(exp(-0.5(A_i(O_i) - n)^2)\right)$EQ(5.3)

5.3 Protection of soil property, environmental protection, and relation of outflow controlling effect

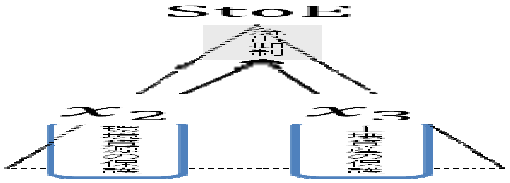


Figure5.3 Block7 Outflow controlling effect factor and the composition factor chart

Recognition to the red-clay-outflow controlling effect obtained by executing the pumpkin intercropping cultivation is composed of recognition concerning the environmental protection, and the coral reef protection. Because two subordinate position factors are related to the outflow controlling effect, environmental resources protection such as coral reef for tourism purpose are thought whether is important from the sugarcane farmer's thinking.

$$StoE_i = 0.52StoE_i(X_{2i}) + 0.48StoE_i(X_{3i}) \quad (R^2 = 0.87)EQ(5,4)$$

$$\varphi(StoE_i(X_{2i})) = \sum_{n=1}^{5} \gamma_{x_2 n} \left(exp(-0.5(StoE_i(X_{2i}) - n)^2)\right)\text{EQ(5.5)}$$

$$\varphi(StoE_i(X_{3i})) = \sum_{n=1}^{5} \gamma_{x_2 n} \left(exp(-0.5(StoE_i(X_{3i}) - n)^2)\right)EQ(5.6)$$

6.1 Sugarcane farmer's surrounding situation reflection model

It was clarified that the sugarcane farmer received the influence of the pumpkin intercropping cultivation execution behavior from a surrounding sugarcane farmer. This shows that execution and the non-execution of the pumpkin intercropping cultivation of a surrounding sugarcane farmer influence it for the lower factor of the Logic model of Peoples' Mind Set by whom the execution desire is decided. Faction-Size Model that derives from the social impact theory by Latane is used to reflect this phenomenon in the MAS model. (REF)

6.2 Faction-size Model

Faction-Size Model of Nowak=Szamrej=Latane is a model by whom the impact of dissenting views is calculated from the number of people who support different opinions in the distance of the persuasive power and others different opinions surroundings. The impact from the person who has the same opinion by using a similar variable is calculated and the opinion by these comparisons has been decided. It is difficult to say that this is a model by which the subject doesn't consider an internal attribute of the subject. The opinion of considering in others' opinions is decided among external factors, and the substance of the subject is shown in Faction-Size Model. Then, it is thought that Faction-Size Model is a model by which a surrounding action is reflected in own consideration factor transformation. It decides the factor to receive a surrounding situation of the lower factors of the execution desire model of the pumpkin intercropping cultivation. It is an interaction model by which surrounding circumstances are reflected in those factors.

$$i_p = N_o^{\frac{1}{2}}\left[\sum \left(s_i/d_i^2\right)/N_o\right]\text{EQ(6.1)}$$

$$i_s = N_s^{\frac{1}{2}}\left[\sum \left(s_i/d_i^2\right)/N_s\right]EQ(6.2)$$

$$i_{pA} = \frac{\left\{ N_{A,G_{In}}\left(N_{A,intG_{In}}\right)^{\frac{1}{2}}\left[\sum_{i=n}^{N_{A,intG_{In}}} \frac{\left(\frac{li_{int,G_{In}}}{d_{Ai}^2}\right)}{N_{A,IntG_{In}}}\right] \right\} + \left\{ N_{A,G_{Ou}}\left(N_{A,intG_{Ou}}\right)^{\frac{1}{2}}\left[\sum_{i=n}^{N_{A,intG_{Ou}}} \frac{\left(\frac{li_{int,G_{Ou}}}{d_{Ai}^2}\right)}{N_{A,IntG_{Ou}}}\right] \right\}}{N_A} EQ(6.3)$$

$i_{pA} =$

$$\frac{\left\{\begin{array}{l} N_{A,G_{In}}\left(N_{A,intG_{In}}\right)^{\frac{1}{2}}\left[\sum_{i=n}^{N_{A,intG_{In}}}\frac{\left(\frac{li_{int,G_{In}}}{d_{Ai}^2}\right)}{N_{A,IntG_{In}}}\right] \\ +N_{A,G_{Ou}}\left(N_{A,intG_{Ou}}\right)^{\frac{1}{2}}\left[\sum_{i=n}^{N_{A,intG_{Ou}}}\frac{\left(\frac{li_{int,G_{Ou}}}{d_{Ai}^2}\right)}{N_{A,IntG_{Ou}}}\right] \end{array}\right\}}{N_A} EQ(6.4)$$

$$i_{s2A} = \frac{\left\{\begin{array}{l} N_{A,G_{In}}\left(N_{A,preG_{In}}\right)^{\frac{1}{2}}\left[\sum_{i=n}^{N_{A,preG_{In}}}\frac{\left(\frac{li_{pre,G_{In}}}{d_{Ai}^2}\right)}{N_{A,preG_{In}}}\right] \\ +N_{A,G_{Ou}}\left(N_{A,preG_{Ou}}\right)^{\frac{1}{2}}\left[\sum_{i=n}^{N_{A,preG_{Ou}}}\frac{\left(\frac{li_{pre,G_{Ou}}}{d_{Ai}^2}\right)}{N_{A,preG_{Ou}}}\right] \end{array}\right\}}{N_A} EQ(6.5)$$

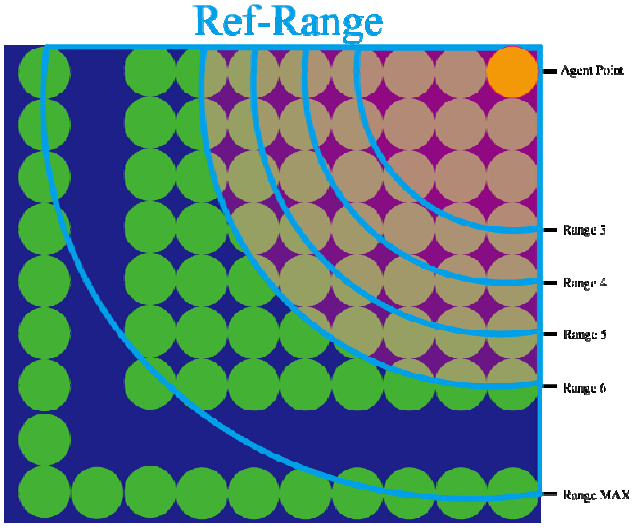
6.3Faction-Size Model applied to phenomenon

Faction-size model used as a situation reflection model among MAS models in this paper is shown in EQ(6.3), EQ(6.4), and EQ(6.5). The (EQ(6.5)) shows the sugarcane farmer who has never been executing the pumpkin intercropping cultivation for influence. The (EQ(6.4)) illustrates the sugarcane farmer who is discontinuing it back and the observation period is expressed though three expressions executed influence. The (EQ(6.2)) is a case of the sugarcane farmer who is continuing the pumpkin intercropping cultivation and the pumpkin intercropping cultivation once. The strength of the influence received from surrounding circumstances is composed of impact strength of the action (impact value), the distance with those who act, and the number of those who act. Moreover, inside group (Belong to the same group as the sugarcane farmer agent) and outside group's (sugarcane farmer agent who doesn't belong to the same group) distinctions are installed. Each impact value as the distance relation to the sugarcane farmer, and the total number of sugarcane farmers in each classification is described. The impact value in Faction-size model sets a uniform value as all agents shown in Table 6.1.

li_{int}		li_f		li_{pre}	
G_{in}	G_{ou}	G_{in}	G_{ou}	G_{in}	G_{ou}
1	0.5	1	0.5	0.05	0.025

Table(6.3) Set value of surrounding situation influence value according to situation

The influence from each classification is 2:1 in this MAS model, and assumes the influence relation from the sugarcane farmer who belongs to the group outside the inside group is 20:20:1 when succeeding, failing, and non-executing it.



Figure(6.1) **Reference range explanatory notes and number of reference agents of sugarcane farmer agent**

Next, the distance and the range when the sugarcane farmer agent refers to the situation of a surrounding sugarcane farmer are described. A case, that the distance and the range of the reference with the referred object were expressed, is shown in Figure (6.1) it shows the sugarcane farmer agent who confirms a certain surrounding situation. It made to range 4 of the maximum reference, and it was assumed to 8 for small reference numbers and 24 for maximum reference numbers in this paper. It cannot be said that the ratio of the in-group decreases when the range expands indiscriminately. It depends on an initial position where the outside group is. Moreover, the distance between the sugarcane farmer agents is used to compare influence strength received from surroundings relative. The method of calculating the distance between agents at this time is between agent's centers. On the other hand, strongly receive

the influence from the group outside the in-group sooner or later when the sugarcane farmer agent observes the situation of surrounding. The sugarcane farmers are either of groups and the number of observations refers to the opinion of the group among the belonging sugarcane farmers. The change of the belonging sugarcane farmer agent of the group and the outside group was comparatively expressed within the range of the observation at dependence. This is one case that influence the sugarcane farmer agent strongly received in some situations. In this issue, the more the range of the reference expands, the more the ratio of the outside group increases.

A	B	C	D
E	F	G	H
I	J	K	L
M	N	O	P

Figure(6.2) **Classification of each village**

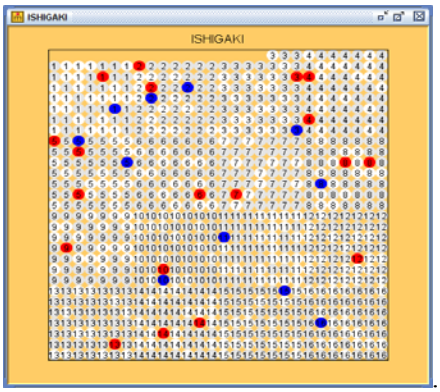
7.1The Ishigaki Island sugarcane farmer's social simulation

The MAS model of the red clay outflow problem of Ishigaki Island that the sugarcane farmer examined the red-clay-outflow control action according to the consideration structure logic model was constructed in the previous section. This part refers to the possibility of the decision making supporting tool of a social simulation according to the constructed MAS model, and confirming behavior in the reproducibility of the phenomenon and each situation.

7.1Verification of achievement reproducibility by MAS model

The validation of the model structure in one of the most important points when the decision making is supported by using the MAS model.

It is thought that validity is secured if the third person can recognize, "It is plausible" an internal structure of the MAS model with validity. It is assumed that the pumpkin production area of the Ishigaki Island is due to the sugarcane farmer's pumpkin intercropping cultivation. The field in the simulation execution environment was shown in Figure (7 1)



Figure(7.1) MAS model output in Artisoc

8.1 Verification of phenomenon reproducibility of MAS model

The harvest risk for the sugarcane farmer agent was set as a scenario in the MAS model. The average recall ratio 75% or more of the period in the harvest risk 20%, 25%, and 30% when judged by the mean value in 100 trials of each Case. The distribution of the simulation result in not only the mean value but also each Step was converted into normal distribution. A similar result obtained reproducibility even by the verification method of setting reproduction Point. Moreover, when the behavior of the simulation was verified after some parameters set to the MAS model were transformed, the change in behavior in the pattern that made the loss ratio when the harvest risk occurred a uniform random number was remarkable. In other words, there were little influences in behavior and the result of the simulation though the parameter value was transformed in the other cases. It is also possible to capture this result as a constructional defect of the

MAS model or to think that it is not a factor that behavior can be decided. It is a problem that will be canceled by the monitoring system and the MAS model's improvement in the future. On the other hand, the loss when the harvest risk occurs because of the pumpkin intercropping cultivation can be said that the MAS model in the pattern is the most logical and high when thinking that it is not uniform but random numbers are nearer because of the realities. The reproducibility in the pattern obtained the result within mean deviation value 45-55 in the period of reproduction, 70 point or more in the harvest risk 10% and 15%. When the realities can be reproduced, it is a digit with the conclusion though the MAS model constructed as a result is condition addition. The statistical information of the pumpkin intercropping cultivation in the sugarcane agriculture doesn't exist as mentioned above, and what of the realities replaces the pumpkin production area in Ishigakiji Island with the pumpkin intercropping cultivation execution area are calculated. It is thought that it is neglected because it adjusts to an improvement of the monitor of the achievement and the MAS model, new theory application. The real data as mentioned above though there is a problem in the accuracy of information that has been treated as the realities.

9.1 Conclusions

The model by which it specialized in actual phenomenon reproducibility was constructed in this paper. The data for a supplementary business promotion can input further in the future for an effective policy making.

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