Collective Activities for the Management of Rural Common-Pool Resources: A Case Study of Irrigation System from Niigata Prefecture, Japan

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1. Introduction

Generally, an appropriate maintenance and management of the common-pool resources (CPRs) in rural areas can contribute to the enhancement of the "quality of life" of inhabitants through improvement of the local environment, etc. (Leeuwen and Nijkamp 2006). In recent years, with the aging of farm households and the rise in the number of non-farm households, it is becoming increasingly difficult for the farm households alone to maintain and manage the CPRs in the farm villages of Japan. Therefore, the cooperation by beneficiaries including non-farm households is considered to be desirable. However such cooperation may be difficult to achieve, as the participation of non-farm households in the management of such resources leads to the diversification of stakeholders.

In this study, we shall firstly review the existing studies on the collective activities for the management of irrigation system. Secondly, by using the framework of social-ecological systems, key issues for the management of the irrigation system in Japan will be clarified. Thirdly, we will clarify the mechanism involved in the management of CPRs through the identification of determinants for activities to manage agricultural irrigation and drainage channels, based on data from the rural community-level in Niigata Prefecture. Finally, we shall draw policy implications and research tasks for the management of the rural CPRs.

2. Literature Review and Methodology

Common-pool resources are systems that generate a finite quantity of resource units such that one person's use subtracts from the quantity of resource units available to others (Ostrom et al. 1994). Irrigation systems are among the most important types of common-pool resources (Ostrom 1992).

With respect to research on the management of common-pool resources, an explanation based on game theory (Dawes 1973; Yabuta 2004) has been offered using theoretical analysis. On the other hand, several approaches based on empirical analyses have been adopted, namely: field research (Ostrom 1990; Bardhan, 2000; Fujie, Hayami and Kikuchi 2001; Sakurai and Palanisami 2001), laboratory experiment research (Ostrom et al. 1994), and simulation research(Lansing and Kremer 1993; Janssen 2002) by using Agent-based Modeling (ABM). In the field research, Ostrom (1990) searches for the ideal way for the institutional design of a system to manage the common-pool resources, based on the result of a number of case studies. In the laboratory experiment, Ostrom et al. (1994) establishes a situation wherein participants face the selection of investment in some combination of private investment and common-pool resource, and then searches for factors mitigating the level of investment in the common-pool resource.

One of the significant findings in this particular study is the importance of communication among the participants. However, the results obtained from the field research and the laboratory experiment do not accord with the forecast obtained from the theoretical model's analysis; in particular, the level of cooperation observed was higher than the level forecast. Moreover, as the National Research Council (2002) had concluded, it is deemed that a unifying form of governance that can be applied to the management of all common-pool resources does not exist.

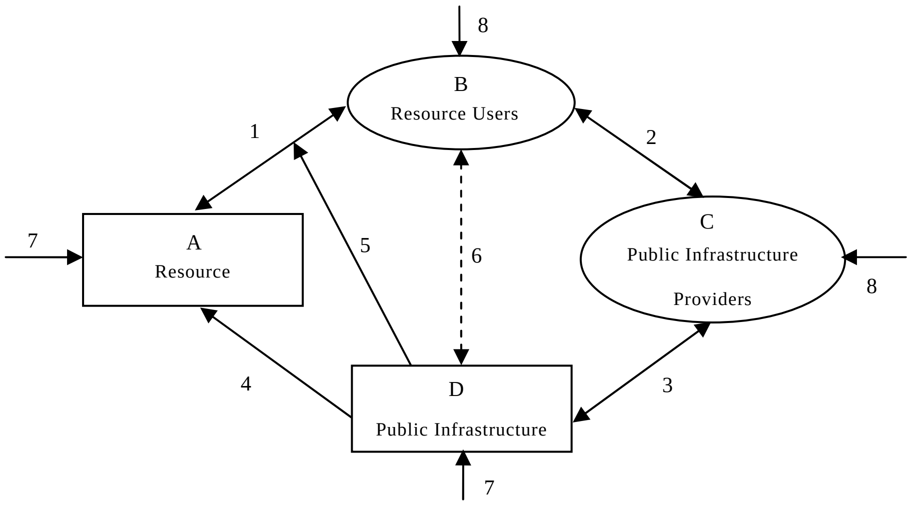
Recently, the ABM approach has been garnering much interest as a means to form a connection between the theory and the reality. ABM is a kind of computer simulation that sets a virtual environment in which a number of agents act (Janssen 2002). These agents, each with different individual preferences and attributes, interact with one another in the environment, and the resulting overall interactive phenomena are analyzed in ABM. By using ABM, assumptions pertaining to, among others, uncertainty and incomplete information can be introduced, and a management system of common pool resources composed of heterogeneous subjects can be analyzed while treating the interaction between subjects explicitly. Moreover, as it is possible to produce a situation representing policy change by setting parameters, simulating the influence of such become possible[1].

While various methods, as indicated above, have been used in research on the management of common-pool resources, neither field research, the laboratory experiment, nor ABM is a perfect methodology, as indicated by Janssen and Ostrom (2006). Therefore, it is necessary to examine the validity and generality of the result obtained, through complementary application of these approaches.

3. Research Framework

3.1 Application of Social-Ecological System to the Management of Irrigation Systems

Here, to arrange the potential problems of facing each element related to the management of the irrigation system, the analytical framework of social-ecological system presented by Anderies et al. (2004) is applied to the management problem of the irrigation system in the Nishi-kanbara region of Niigata Prefecture. In a conceptual framework of the social-ecological system, it is thought that the system is composed of four entities: resource, public infrastructure, public infrastructure providers, and the resource users (Fig.1).



Source: Anderies et al. (2004)

Fig.1 A conceptual model of a social-ecological system

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[1] For example, please see Balmann et al. (2001) which studied the impact of agri-environmental policy change on agricultural system in German Region for example.

The entities and each relation of the irrigation system in the Nishi-kanbara region of Niigata Prefecture are summarized in Table 1 and Table 2. The point that should be given particular attention is the influence that the mixing of suburbs and agricultural areas, due to an increase in non-farm households, has on the management system (Furuzawa and Kiminami 2004). In addition, as differences exist between farmers in terms of individual objectives (e.g. economic-intention and environmental-intention), consensus building between farmers becomes arduous (Furuzawa and Kiminami 2007). In a word, it is necessary (a) to specify externality and (b) to consider the problem of the consensus building between farmers and between the farmers and non-farmers in the analysis of the management system of the irrigation facilities.

Table 1. Entities of irrigation system involved in social-ecological systems (example of Nishi-kanbara, Niigata prefecture)

Entities, External Factors	Examples of the Application of Irrigation System	Potential Problems
(A)Resource	Water Biodiversity Land	Uncertainty Complexity, Uncertainty
(B)Resource Users	Farmers(Economic Intention and Environmental Intention) Non-farmers	Abandoned Cultivated Land, Free Ride Illegal Dumping of the Waste, Free Ride
(C) Public Infrastructure Providers	Land Improvement District(Farmer's Association) Government(Central Government, Local Government)	Domestic Consensus Building Financial Crunch
(D)Public Infrastructure	Irrigation Facilities	Maintenance and Management, Renewal Investment, Externality(Positive and Negative)
External Factors	Natural Disaster Macro Economy Climate Change Political System Policy Change	Flood, Earthquake Variation in the Price of Agricultural Products (Declining of Rice Price), Variation in the Price of Production Factor, Shrinkage of Market etc. Sudden Meteorological Change Consolidation of Municipalities, Replacement of Governor and Mayor "Measures to Conserve and Improve Land, Water and Environment"

Source: Made based on authors' existing researches in the framework of Anderies et al.(2004)

Table 2. Links involved of irrigation system in social-ecological system (example of Nishi-kanbara, Niigata prefecture)

Link	Examples of the Application of Irrigation System	Potential Problems
(1)Resource and Resource Users	Farmers: Water Use for Farming, Controling of Harmful Insects by Using Pesticides Non-farmers: Indirect Use	Deterioration of Water Quality, Fluctuation Water Flow, Degradation of Biodiversity
(2)Users and Public Infrastructure Providers	Land Improvement District and Farmers: Imposed Amount, Voting Land Improvement District and Non-farmers: Provision of Labor Force (Financial Support) Government and Farmers: Subsidization, Tax Imposition Government and Non-farmers: Tax Imposition	Disagreement in Opinion Free Ride Rent Seeking
(3)Public Infrastructure Providers and Public Infrastructure	Land Improvement District and Irrigation Facility: Construction, Maintenance and Management Land Improvement District and Institution: Drawing Up of Rules about Resource Use and Maintenance and Management, Monitoring, Enforcement of Rules Government and Irrigation: Subsidy Government and Institution: Policy Implementation	Excess (Underrated) Investment Cost(Consensus Building, Monitoring) Contract Enforcement Rent Seeking Inaccuracy of Impact Assessment
(4)Public Infrastructure and Resource	Irrigation Facility: Impact on Water Availability/Accessibility, Habitat Environment	Low Level of Water Quality
(5)Public Infrastructure and Resource Dynamics	Economic Effect: Improvement of Efficiency of Resource Use, Reduction of Risk Externality: External Economy(Mulit-functionality), External Diseconomy	Declining of Economic Effect, Growth of Environmental Burden
(6)Resource Users and Public Infrastructure	Farmers: Use, Maintenance and Management Non-farmers: Indirect Use, Maintenance and Management(Partial)	Slumping Business, Impact on Farmland Market Free Ride
(7)External Forces on Resource and Infrastructure	Flood, Earthquake	Destruction of Infrastructure
(8)External Forces on Social Actors	Change of Political System Demographics(Migration, Declining Birthrate and Aging of Population) Change of Economic Environment	Conflict Preference Change, Shrinkage of Market, Fluctuation of Land Price Impact of International Trade Negotiation of Agricultural Products

Source: Made based on author's existing researches in the framework of Anderies et al.(2004)

3.2 Examination of Policy

"Measures to Conserve and Improve Land, Water and Environment" have been executed since fiscal 2007 (until the fiscal 2001). Land, Water and Environment Measures consist of two measures, namely environmentally-friendly agriculture measures aiming to support advanced farming activities, and the regional resource conservation measures aiming to support collaborative activities in the community.

Support for collaborative activities is in the form of a subsidy provided to regions where non-farmers also execute the maintenance and management of regional resources. The amount of the subsidy is calculated according to the area of the particular region, and support consists of a basic stage and a preparatory stage. In the case of advanced farming activities support, when the farmers executed environmentally-friendly agriculture in the region of collaborative activities support, the subsidy is delivered.

The collaborative activities support is thought to reduce the overall cost of consensus building and implementation of management, hence it promotes management activities of common-pool resources. On the other hand, the support for advanced farming activities assumes the existence of collaborative activities support in the same region; thus, a problem arises wherein the choices involved in the decision-making process for farmers are limited (Shogenji 2008).

4. Empirical Analysis

4.1 Present conditions of rural communities and agricultural irrigation and drainage channels in Japan

According to the Agricultural Census in fiscal 2005, there exist 139,465 rural communities in Japan. These rural communities are regional communities that formed for agricultural purposes within areas of the municipal zones. As the rural communities were originally spontaneously formed, the basic unit for social life formed in the various groups and social relations through territorial or blood relationship. More specifically, the rural community is a community for production and life closely tied not only to the aspects of farm management (e.g. maintenance/management of farm roads, water systems, and jointly owned forest land), the use of various buildings and agricultural instruments, labor (e.g. mutual help, assistance), and the cooperative shipping of agricultural products, but also to the aspects of life (e.g. important ceremonial occasions within and between families) that have helped these communities function as autonomous, administrative units.

Agricultural irrigation and drainage channels exist in 87.6% of all rural communities (122,110 villages). In 60.2% of these rural communities (73,487 communities), the agricultural irrigation and drainage channels are repaired, cleaned, and managed. In most communities, the facility maintenance activities performed are based on regional agreement, chiefly by the local residents (see Table 3). Furthermore, many of these rural communities perform the maintenance of agricultural irrigation and drainage channels for purposes other than agricultural production, including preservation of water resources and land (see Table 4). Thus, the agricultural irrigation and drainage channels are a common-pool resource with multiple functions, maintained through the joint activities of local residetns(OECD 2001; OECD 2003).

Table 3. Reasons and actors for management of agricultural irrigation and drainage channels

	Reasons for management			Main actors of management		
					Local residents etc.	
	Prefectural ordinance	Municipal bylaw	Agreement	Local public entities	Including outside of rural community	Rural community alone
Number of rural communities	299	1895	71293	2040	14435	57012
(%)	(0.4)	(2.6)	(97.0)	(2.8)	(19.6)	(77.6)

Source: "Census of Agriculture and Forestry 2005: Survey on Rural Area (for Rural Community)"

Table 4. Purpose of management of agricultural irrigation and drainage channels(multiple selection)

	National land conservation	Water resources conservation	Living animate beings conservation	Landscape conservation	Tourism resource conservation	Others
Number of rural communities	11,395	31,286	1,551	10,069	219	41,604
(%)	(15.5)	(42.6)	(2.1)	(13.7)	(0.3)	(56.6)

Source: "Census of Agriculture and Forestry 2005: Survey on Rural Area (for Rural Community)"

4.2 Analysis on the management of common-pool resources

4.2.1 Data

The analysis was performed based on the data by communities contained in the *2000 World Census of Agriculture and Forestry: Survey on Rural Communities*. It should be noted that though the latest version of the *Census of Agriculture and Forestry* is the year 2005 version, the data as of the year 2000 version was used, as the data of 2005 version doesn't summarize the implementation method of collective activities. There are 4,704 rural communities in Niigata Prefecture, of which 4,489 villages, except for those villages lacking agricultural irrigation and drainage channels within them and villages with no statistical information available, were targeted for the analysis.

4.2.2 Analytical methods

To begin with, the maintenance status of the agricultural irrigation and drainage channels were clarified. There are three management methods relative to the irrigation and drainage channels: Services rendered by all households, services rendered only by farm households, and services rendered by employed persons.

Secondly, the correlations between the activities to manage agricultural irrigation and drainage channels and the distinctive features of rural communities were clarified through cross-tabulation analysis and discriminant analysis. The distinctive features of the communities are composed of the naturally, socially, and economically distinctive features in association with the land use, members, and location. The indicators used for the analysis were selected with reference to Fujie (2007)[2].

The ratio of paddy fields in the cultivated land and the ratio of abandoned cultivated land were adopted as indicators representing the distinctive features of land use; community size (number of households), the ratio of Type II part-time farm households[3], the ratio of non-farm households, and the frequency of community gathering were adopted as indicators representing the distinctive features of the members; and the distance to the DID

2 Although Fujie (2007) studied the determinant factors of collective activity for irrigation facility in Shiga Prefecture, it didn't analyze the factors in the framework of cost-benefit calculus.

3 Full-time farm household is one that consists of no member who works outside of the family farm operation.
Part-time farm household is one that consists of at least one member who works outside of family farm operation.
Type I part-time farm household refers to a farm household that principally subsists on farm income.
Type II part-time farm household refers to a farm household that principally subsists on non-farm income.

(densely-inhabited district), areal type, topographic features, and community type were adopted as indicators representing the distinctive features of the location.

Characteristics of rural communities and implementation of management activity

Scott (1993) pointed out that, instead of focusing solely on community size or the various kinds of heterogeneity, it is important to ask how these variables affect other variables, as they impact the cost-benefit calculus of those involved in negotiating and sustaining agreements. The impact of these two variables on the costs of producing and distributing information is particularly important (Ostrom 2002).

Here, the influence that the characteristic variable of rural communities has on the cost and benefit of the management activity is examined, and the sign condition is predicted theoretically. Cost is divided into cost of consensus building (C_{CB}) and implementation of management (C_{IM}), and benefit is divided into agricultural benefits (B_{AG}) and non-agricultural benefits (B_{NA}). Then, the implementation condition of the management activity of agricultural irrigation facility can be written as follows (LU, CM, and LC show the land use, the constituent members, and the location, respectively).

$$B_{AG}(LU, CM, LC) + B_{NA}(LU, CM, LC) > C_{CB}(LU, CM, LC) + C_{IM}(LU, CM, LC) \quad (1)$$

The characteristics of rural communities are considered to have the following effects on the benefits and cost of performing activities to manage agricultural irrigation and drainage channels (see Table 5). Regarding Land Use (LU), in terms of the ratio of paddy fields in the cultivated land, a higher ratio indicates higher agricultural income and higher positive externality, and hence indicates higher agricultural benefits. In addition, as a higher ratio of paddy field management indicates the higher homogeneity of farm households, resulting in the lower cost of consensus building, it is considered to be a contributor to the promotion of management activities. With respect to the ratio of the abandoned cultivated land, as a higher ratio indicates higher declination of regional agriculture, resulting in both lower agricultural and non-agricultural benefits (e.g. landscape deterioration), it is considered to be a contributor to the inhibition of management activities.

As for the Constituent Members (CM), community size is also a major factor. As larger communities require more cost for consensus building, the size of the community is considered to correlate with the inhibition of management activities. In terms of the ratio of Type II part-time farm households, a higher ratio indicates lower dependence of farm households on agriculture, and hence the lower agricultural benefits and higher evaluation of non-agricultural benefits. In addition, with Type II part-time farm households representing the majority of the farm households, a higher ratio means a higher heterogeneity among farm households and hence a higher cost for consensus building. However, in this case, the effect on management activities depends on the scale of the respective benefits and costs. With respect to the non-farm household ratio, given that a higher ratio means lower regional dependence on agriculture and higher evaluation of non-agricultural values, it contributes to the lowering of agricultural benefits and the increase of non-agricultural benefits. On the other hand, a higher non-farm household ratio results in an increase in the cost for consensus building due to increased diversification of the members. Accordingly, the effect on management activities depends on the size of the respective costs and benefits. In regard to the frequency of community gathering, as a higher ratio indicates smoother performance of management activities and hence a lower cost for consensus building, a higher frequency of community gathering is considered to promote management activities.

As for Location (LC), concerning the distance to the DID and the type of the agricultural area, since a higher extent of urbanization means larger non-agricultural benefits, urbanization is considered to promote the management activities. In terms of the topographic features, as better conditions mean larger agricultural benefits and hence a lower cost for management implementation, better topographic features are considered to promote management activities. Finally, with respect to the community type, since a higher density of houses means a lower cost for consensus building, a higher house density is considered to promote management activities.

Table 5. Benefit and cost by management activity of agricultural irrigation and drainage channels

Characteristics of rural community	Benefit		Cost		Projected effect of management activity
	Agriculture	Non-agriculture	Implementation	Consensus Building	
Land Use					
Ratio of paddy fields	+	+	0	-	+
Ratio of abandoned cultivated land	-	-	0	0	-
Constituent member					
Community size	0	0	0	+	-
Ratio of type II part-time farm households	0	+	0	+	?
Ratio of non-farm households	-	+	0	+	?
Frequency of community gathering	0	0	-	-	+
Location					
Distance to DID(Near-Far)	0	+	0	0	+
Areal type (Urban-Mountain)	0	+	0	0	+
Topographic features Good-Bad)	+	0	-	0	+
Community type (Density: High-Low)	0	0	0	-	+

Characteristics of rural communities and implementation method of management

The next topic is the influence of the characteristics of rural communities on the management implementation method for agricultural irrigation and drainage channels. This section discusses the selection of representative service-rendering systems; that is, the system of services rendered by all households and the system of services rendered by farm households. While the services rendered by all households may be evaluated to be more desirable from the perspective of joint management of common-pool resources, no significant difference in benefits is likely to be caused by a difference in management system. Accordingly, if the ratio of the cost for the system of services rendered by farm households to that of the cost for the system of services rendered by all households is low, it is considered more likely that the latter system would be selected. Then, the selection condition of the all households' method can be written as follows (1 and 2 of the affixing characters show the all households' method and farm households' method respectively).

$$C_{CB1}(LU, CM, LC) + C_{IM1}(LU, CM, LC) < C_{CB2}(LU, CM, LC) + C_{IM2}(LU, CM, LC) \quad (2)$$

Table 6 shows a summary of the characteristics of rural communities likely to affect the selection of the system of services rendered by all households. First of all, it is considered that land use does not influence the selection of the implementation method, as there is no difference in cost between the all households' method and the farm households' method. As for Constituent Members (CM), in terms of community size, if the size is larger, a higher coordination cost will be required for participation by all members, and therefore it is considered less likely that the system of services rendered by all households will be selected. In contrast, with respect to the ratio of Type II part-time farm households, if the ratio is higher, management activity rendered by farm households will become difficult, and therefore it is considered more likely that the system of services rendered by all households will be selected. Looking at the ratio of non-farm households, if the ratio is higher, the diversity of members will become higher, and therefore it is less likely that the system of services rendered by all households will be selected.

As for Location (LC), in terms of the distance to the DID and the areal type, if the level of standardization is above or below a certain level, the homogeneity of members rises. In such a case, it is considered more likely that the services rendered by all households will be selected. Finally, with respect to the residential density, if the ratio is higher, lower cost will be required for the coordination of the services rendered by all households, and therefore it is considered more likely that the services rendered by all households will be selected.

Table 6. Management method and cost of agricultural irrigation and drainage channels

Characteristics of rural community	Cost of farm households method / Cost of all households method	Projected effect of management activity
Land Use		
Ratio of paddy fields	0	0
Ratio of abandoned cultivated land	0	0
Constituent member		
Community size	-	-
Ratio of type II part-time farm households	+	+
Ratio of non-farm households	-	-
Frequency of community gathering	0	0
Location		
Distance to DID(Near-Far)	+/-	+/-
Areal type (Urban-Mountain)	+/-	+/-
Topographic features Good-Bad)	0	0
Community type (Density: High-Low)	+	+

4.3 Analytical results

4.3.1 Present state of activities to manage the agricultural irrigation and drainage channels

Table 7 shows the status of the maintenance of agricultural irrigation and drainage channels. In 3,981 (88.7%) of the 4,489 rural communities, the agricultural irrigation and drainage channels are maintained. The table shows that the common-pool resources are generally maintained by local residents, though the system of services rendered only by farm households is dominant.

Table 7. Status of the maintenance of agricultural irrigation and drainage channels

	Managed			Not managed
	All households	Only farm households	Employed persons	
Number of rural community	1,291	2,626	64	508
(%)	(28.8)	(58.5)	(1.4)	(11.3)

Source: "2000 World Census of Agriculture and Forestry: Survey on Rural Communities"

4.3.2 Correlations between the characteristics of rural communities and the activities to manage the agricultural irrigation and drainage channels

Table 8 shows the results of discriminant analysis on the relationship between the characteristics of rural communities and the presence/absence of activities to manage the agricultural irrigation and drainage channels. The results showed that the discrimination ratio was 67.3% and that significant factors were obtained with the following parameters: the ratio of paddy field area in the cultivated land, the ratio of Type II part-time farm households, the frequency of community gathering, the distance to the DID, the topographic features, and the community type. The result of the theoretical examination is generally consistent with the result of the quantitative analysis, revealing that the parameter of community size is not significant, thus indicating that the increase of members has little effect on the cost of consensus building. Furthermore, the results revealed that the ratio of Type II part-time farm households has a positive effect, indicating that the effect of the increased non-agricultural benefits and the lowered cost for consensus building is larger than the effect of the decreased agricultural benefits. Moreover, the parameter of the ratio of non-farm households is not significant, indicating that the effect of the decreased agricultural benefits and the increased cost for consensus building is larger than the effect of the increased non-agricultural benefits.

Table 8. Discriminant analysis on the correlations between the characteristics of rural communities and the presence/absence of activities to manage the agricultural irrigation and drainage channels

	Standardized DC(Discriminant Coefficient)	Partial F-Value	P-Value
Land Use			
Ratio of paddy fields	0.13	5.64	0.018 **
Ratio of abandoned cultivated land	-0.08	2.17	0.141
Constituent Member			
Community size	0.00	0.00	0.979
Ratio of type II part-time farm households	0.20	13.10	0.000 ***
Ratio of non-farm households	-0.01	0.05	0.816
Frequency of community gathering	0.17	11.47	0.001 ***
Location			
Distance to DID(Basis="~ 30 minutes"			
"30 minutes ~ 1 hour" Dummy	-0.16	7.82	0.005 ***
"1 ~ 1.5 hour" Dummy	-0.04	0.47	0.495
"1.5 hour ~ "Dummy	-0.04	0.76	0.384
Areal type(Basis="Hilly agricultural area"			
"Urban-area" Dummy	0.07	1.27	0.260
"Flat agricultural area" Dummy	0.00	0.01	0.941
"Mountainous agricultural area" Dummy	-0.06	1.09	0.296
Topographical features(Basis="Plains")			
"Basin-shaped valleys" Dummy	-0.01	0.02	0.893
"Plateaus" Dummy	-0.01	0.06	0.805
"Ranges" Dummy	-0.14	6.95	0.008 ***
"Mountainous area" Dummy	0.14	4.28	0.039 **
"Canyons" Dummy	0.01	0.02	0.889
Community type (Basis="Communities with households in groups")			
"Scattered communities" Dummy	-0.12	4.41	0.036 **
"Communities with scattered" Dummy	-0.29	32.99	0.000 ***
"Communities with densely located households" Dummy	0.00	0.01	0.934
Constant	-1.49		
Sample size	4,489		
Discrimination Ratio	67.34%		

Note: '***', '**' and '*' indicate level of significance 1 % and 5 % respectively.
Dependent variable indicate 'Managed=1' and 'Not managed=0'.

Table 9 shows the results of discriminant analysis on the correlations between the characteristics of rural communities and the method to implement management of agricultural irrigation and drainage channels. The results showed a discrimination ratio of 68.8% and that statistically significant factors were obtained with the following parameters: the ratio of Type II part-time farm households, the ratio of non-farm households, the distance to the DID, the areal type, and the topographic features. The result of the theoretical examination is generally assessed to be consistent with the result of the quantitative analysis.

Table 9. Discriminant analysis on the correlations between the characteristics of rural communities and the method to implement management of agricultural irrigation and drainage channels

	Standardized DC(Discriminant Coefficient)	Partial F-Value	P-Value
Land Use			
Ratio of paddy fields	0.03	0.56	0.453
Ratio of abandoned cultivated land	0.00	0.01	0.930
Constituent Member			
Community size	0.01	0.04	0.837
Ratio of type II part-time farm households	0.16	13.57	0.000 ***
Ratio of non-farm households	-0.58	138.53	0.000 ***
Frequency of community gathering	-0.05	2.00	0.158
Location			
Distance to DID(Basis="~ 30 minutes"			
"30 minutes ~ 1 hour" Dummy	-0.10	5.19	0.023 **
"1 ~ 1.5 hour" Dummy	-0.14	11.71	0.001 ***
"1.5 hour ~ "Dummy	-0.02	0.18	0.668
Areal type(Basis="Hilly agricultural area"			
"Urban-area" Dummy	-0.14	7.31	0.007 ***
"Flat agricultural area" Dummy	-0.24	22.23	0.000 ***
"Mountainous agricultural area" Dummy	0.04	0.80	0.372
Topographical features(Basis="Plains")			
"Basin-shaped valleys" Dummy	0.45	107.95	0.000 ***
"Plateaus" Dummy	0.20	27.34	0.000 ***
"Ranges" Dummy	0.02	0.15	0.700
"Mountainous area" Dummy	0.29	29.11	0.000 ***
"Canyons" Dummy	0.16	15.38	0.000 ***
Community type (Basis="Communities with households in groups")			
"Scattered communities" Dummy	0.07	2.33	0.127
"Communities with scattered" Dummy	-0.02	0.17	0.684
"Communities with densely located households" Dummy	-0.06	1.84	0.175
Constant	0.19		
Sample size	3,917		
Discrimination Ratio	68.83%		

Note: '***', '**' and '*' indicate level of significance 1 % and 5 % respectively.
Dependent variable indicate 'All households working=1' and 'Farm households working=0'.

5. Conclusion

The analyses of this study revealed, firstly, that both the feasibility and the implementation method of the management of agricultural irrigation and drainage channels in rural communities are significantly influenced by the geographical, social, and economic features of the community. Secondly, the analyses indicated that while the diversification of stakeholders resulting from the increase of urbanized members in communities leads to the increased cost of consensus building in joint activities for common-pool resources, it also has the effects of enhancing the evaluation for non-agricultural values of resources and supplementing the ability of weakened farm households to manage the resources.

Accordingly, it may be said that in order to appropriately manage common-pool resources, measures should be taken in accordance with the characteristics of communities implementing the management. In addition, the author considers that, in light of the present status of farm villages in Japan, it is important to develop a system encouraging non-farm households to participate in the management of common-pool resources.

However, in the empirical analysis the focus was only applied to two elements of resource users (farmers and non-farmers) and public infrastructure (agricultural irrigation facilities) indicated in section 3. It is also a fact, however, that there remain parts that cannot be accounted for by the characteristics of communities that were analyzed in this study. Thus, it is a future issue to deepen the study on factors influencing the joint management activities for common-pool resources other than those relating to the characteristics of communities.

Moreover, it had been considered that the “Measures to Conserve and Improve Land, Water and Environment” that have been in place since fiscal 2007 effected the establishment of the common-pool resources management system in the region. However, it is necessary to consider that the management of the common-pool resource in the region is actually performed in light of several concurrent interactions between public infrastructures (institutions and physical infrastructures), resource users, public infrastructure providers, and the resources etc., and to examine the policy in the framework. Therefore, analysis of the influence of this policy via agent-based model simulations is deemed necessary as a future research task.

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References

Anderies, J.M., Janssen, M. and Ostrom, E. (2004): “A framework to analyze the robustness of social ecological systems from an institutional perspective” *Ecology and Society*, 9 (1), 18.

Balmann, A., Happe, K., Kellermann, K. and Kleingarn Anne. (2002): “Adjustment cost of agri-environmental policy switchings: an agent-based analysis of the German region Hohenlohe” in Janseen(2002), pp.127-157.

Bardhan, P. K.(2000): “Irrigation and cooperation: an empirical analysis of 48 irrigation communities in South India” *Economic Development and Cultural Change*, 48(4), pp.847-865.

Dawes, R. M. (1973): “The commons dilemma game: An N-person mixed-motive game with a dominating strategy for defection” *Oregon Research Institute Research Bulletin*, 13, pp.1-12.

Fujie, M., Hayami, Y. and Kikuchi, M. (2000): “The conditions of collective action for local commons management: the case of irrigation in the Philippines” *Agricultural Economics*, 33(2), pp.179-189.

Fujie, T. (2007): “Collective action for the management of rural common-pool resources: the case of rural communities in Shiga prefecture” *Science for Environment & Sustainable Society*. 4(1), pp.73-82 (in Japanese).

Furuzawa, S. and Kiminami, L.Y.(2004): "Impacts of Resident's Consciousness on Rural Infrastructure", *Papers in the Agricultural Economics Society of Japan 2004*, pp.302-307 (in Japanese)

Furuzawa, S. and Kiminami, L. Y. (2007): "Perception Formation and Choice of Farm Households about Land Improvement Projects: An Empirical Study on Niigata Prefecture, Japan", *Studies in Regional Science*, Vol.36(4), pp.839-852 (in Japanese)

Janssen. M. A. ed (2002): *Complexity and ecosystem management: the theory and practice of multi-agent systems*. Edward Elgar, Cheltenham, U.K.

Janssen, M. A. and Ostrom, E. (2006): "Governing social-ecological systems" *Handbook of Computational Economics*, Volume 2, pp.1466-1509

Kiminami, L.Y. and Kiminami, A. (2004): "Effects of Rural Environment on Children's Consciousnesses of Future Profession", *Japanese Journal of Farm Management,* Vol.42(2), pp.83-87 (in Japanese)

Lansing,S.J.and Kremer, J.N. (1993) "Emergent Properties of Balinese water temple networks: coadaptation on a rugged fitness landscape" *American Anthropologist*, 95, pp.97-114.

Leeuwen, E. S. van and Nijkamp, P. (2006): "The urban-rural nexus—a study on extended urbanization and the hinterland" *Studies in Regional Science,* 36(2), pp.283-303.

National Research Council. (2002): *The Drama of the Commons*. Committee on the Human Dimensions of Global Change. National Academy Press

OECD. (2001): *Multifunctionality: Towards an Analytical Framework*. OECD Publishing, Paris.

OECD. (2003): *Multifunctionality: The Policy Implications*. OECD Publishing, Paris

Ostrom, E. (1990): *Governing the Commons*. Cambridge University Press, New York

Ostrom, E. (1992): *Crafting Institutions for Self-Governing Irrigation Systems*. Institute of Contemporary Studies Press. New York

Ostrom, E., Gardner, R. and Walker, J. (1994): *Rules, Games, and Common-Pool Resources*. University of Michigan Press. Ann Arbor

Ostrom, E.(2002): "Common-pool resources and institutions—toward a revised theory" *Handbook of Agricultural Economics*. 2, pp.1315-1339

Shogenji, S.(2008): *Rebuilding Agriculture*, Iwanami Shoten, Tokyo(in Japanese)

Sakurai, T. and Palanisami, K.(2001): "Tank irrigation management as a local common property: the case of Tamil Nadu, India" *Agricultural Economics* 25:2-3, pp.273-283

Scott, A.(1993): "Obstacles to fishery self-government" *Marine Resource Economics*. 8, pp.187-199

Yabuta, M.(2004): *Common Pool.* Shinhyou-ron, Tokyo (in Japanese)