

IMPACT EVALUATION OF AGRICULTURAL ENVIRONMENT CONSERVATION PROGRAM (AECPP) USING WATER-FOOD-ENERGY NEXUS PLATFORM (NEWS) IN KOREA

ÉVALUATION DE L'IMPACT DU PROGRAMME DE CONSERVATION DE L'ENVIRONNEMENT AGRICOLE (AECPP) À L'AIDE DE LA PLATEFORME «LIENS ENTRE EAU-ALIMENTATION-ÉNERGIE» (NEWS) EN CORÉE

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ABSTRACT

In the 'Agricultural Innovation, Productivity, and Sustainability Report in Korea,' the OECD made various policy recommendations for achieving sustainable agriculture and agricultural innovation, based on an analysis of Korea's agricultural conditions and policies. Agricultural activities are negatively impacting the rural environment during crop cultivation. Crop cultivation activities accompany the degradation of rural environmental resources, including tillage, chemical application, nutrient supply, and water consumption. The Ministry of Agriculture, Food and Rural Affairs (MAFRA) of South Korea has implemented the Agricultural Environment Conservation Program (AECPP) to conserve natural resources and landscapes in rural areas. The AECPP involves two activity folds: village-level and farmer-level activities. Each category includes conservation activities related to the agricultural environment. The AECPP includes 5 categories: soil, water, landscape, atmosphere, and heritage & ecology. The soil category includes nutrient management, soil erosion prevention, pesticide reduction, and related activities. The water category includes water quality improvement, non-point pollution source management, agricultural water conservation, etc., and the atmosphere category includes greenhouse gas reduction, axonal odor reduction, etc. The heritage and ecology category include enhancing biodiversity and conserving ecosystems, among other activities. In this study, activities from the soil, ecology, atmosphere, and water categories are selected for quantitative evaluation. The AECPP program is a direct payment program to which participants are eligible, and MAFRA has to evaluate the effectiveness of AECPP in terms of environmental and economic benefits. Therefore, the platform NEWS (Nexus Environmental Working for Sustainability) based on nexus approach was developed to evaluate the AECPP activities effectiveness. The platform NEWS integrates database, models, and UI (User Interface) into a seamless system to provide AECPP activity monitoring and evaluation. The database contains digital maps for soil and land ownership parcels and information about the participants, and the APEX model embedded in the platform to calculate water balance, soil and nutrient losses, and GHG emissions. UI also adapted to provide the graphical results. The NEWS has two functions that include AECPP implementation monitoring and impact evaluation. The implementation monitoring function enables checking the progress status of participants' activities. The impact evaluation function provides capabilities for the effectiveness of activities in terms of environmental improvements in terms of quality and economic value based on scenarios and activities. The APEX model is used to calculate the water quality of runoff from the farmlands during the application of AECPP cultivation activities and provides the

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results to the economic analysis model for value accounting of the AECP activities. The NEWS successfully analyzed the relationship between various cultivation activities included in the AECP and agricultural resources and quantitatively analyzed the impact of cultivation activities such as water management, fertilizer management, tillage management, and conservation practices. The NEWS platform was applied to 59 villages participating in the AECP implementation for data collection, program monitoring, and impact evaluation, and scenarios were analyzed for comparison. The NEWS platform demonstrated how the database and model-based system can be applied for governmental policy implementation and evaluation in an agricultural direct payment program, adapting the water-food-energy nexus approach. As such, the water-food-energy nexus studies are expected to serve as foundational data to support a policy decision-making tool by comprehensively analyzing and quantitatively evaluating the impacts of climate change and agricultural cultivation activities on resources and between resources.

Keywords: Agricultural Environment Conservation, Water-Food-Energy Nexus, NEWS platform, Agricultural Program Evaluation.

RESUME

Selon son «Rapport sur l'innovation, la productivité et la durabilité agricoles en Corée», l'OCDE a formulé diverses recommandations politiques visant à réaliser une agriculture durable et à favoriser l'innovation agricole, sur la base d'une analyse des conditions et des politiques agricoles coréennes. Les activités agricoles exercent un impact négatif sur l'environnement rural lors de la culture des plantes. Ces activités agricoles entraînent une dégradation des ressources environnementales rurales, notamment en raison du travail du sol, de l'épandage de produits chimiques, de l'apport de nutriments et de la consommation d'eau. Le ministère de l'Agriculture, de l'Alimentation et des Affaires rurales (MAFRA) de Corée du Sud a mis en œuvre le Programme de conservation de l'environnement agricole (AECP) afin de préserver les ressources naturelles et les paysages des zones rurales. L'AECP comprend deux volets d'activités : celles menées au niveau des villages et celles menées au niveau des agriculteurs. Chaque catégorie comprend des activités de conservation liées à l'environnement agricole. L'AECP comprend 5 catégories : les sols, l'eau, les paysages, l'atmosphère, ainsi que le patrimoine et l'écologie. La catégorie «sols» couvre la gestion des nutriments, la prévention de l'érosion des sols, la réduction d'usages des pesticides et les activités y relatives. La catégorie «eau» inclut l'amélioration de la qualité de l'eau, la gestion des sources de pollution diffuses, la conservation de l'eau à des fins agricoles, etc., tandis que la catégorie «atmosphère» comprend la réduction des gaz à effet de serre, la réduction des nuisances olfactives, etc. La catégorie «Patrimoine et écologie» se compose, entre autres, du renforcement de la biodiversité et de la conservation des écosystèmes. Dans cette étude, les activités issues des catégories «Sol», «Écologie», «Atmosphère» et «Eau» sont retenues pour faire l'objet d'une évaluation quantitative. Le programme AECP est un programme de paiements directs auquel les participants sont admissibles, et le MAFRA doit évaluer l'efficacité de l'AECP en termes d'avantages environnementaux et économiques. Par conséquent, la plateforme NEWS (Nexus Environmental Working for Sustainability), fondée sur l'approche «lien», a été développée pour évaluer l'efficacité des activités de l'AECP. La plateforme NEWS intègre une base de données, des modèles et une interface utilisateur (UI) au sein d'un système homogène afin d'assurer le suivi et l'évaluation des activités de l'AECP. La base de données se compose des cartes numériques des parcelles foncières et des informations relatives aux participants, tandis que le modèle APEX intégré à la plateforme permet de calculer le bilan hydrique, les pertes de sol et de nutriments, ainsi que les émissions de gaz à effet de serre. L'interface utilisateur a également été adaptée pour fournir les résultats sous forme graphique. Le NEWS dispose de deux fonctions : le suivi de la mise en œuvre de l'AECP et l'évaluation d'impact. La fonction de suivi de la mise en œuvre permet de vérifier l'état d'avancement des activités des participants. La fonction d'évaluation d'impact permet d'analyser l'efficacité des activités en ce qui concerne les améliorations environnementales, tant sur le plan de la qualité que de la valeur économique, en se basant sur des scénarios et d'activités. Le modèle APEX est utilisé pour calculer la qualité de l'eau de ruissellement provenant des terres agricoles pendant la mise en œuvre des activités agricoles de l'AECP et fournit les résultats au modèle d'analyse économique pour la comptabilisation de la valeur des activités de l'AECP. Le système NEWS a permis d'analyser avec succès la relation entre les différentes activités agricoles incluses dans l'AECP et les ressources agricoles, et d'analyser

quantitativement l'impact des activités agricoles telles que la gestion de l'eau, la gestion des engrais, la gestion du travail du sol et les pratiques de conservation. La plateforme NEWS a été mise en œuvre dans 59 villages participant à la mise en œuvre de l'AECP à des fins de collecte de données, de suivi du programme et d'évaluation d'impact, et des scénarios ont été analysés à des fins de comparaison. La plateforme NEWS a démontré la manière dont la base de données et le système basé sur des modèles peuvent être appliqués à la mise en œuvre et à l'évaluation des politiques gouvernementales dans le cadre d'un programme de paiements directs agricoles, en adaptant l'approche du lien entre eau-alimentation-énergie. À ce titre, les études sur le lien entre eau-alimentation-énergie devraient servir de données fondamentales pour soutenir un outil d'aide à la décision politique, en analysant de manière exhaustive et en évaluant quantitativement les impacts du changement climatique et des activités agricoles sur les ressources, ainsi que des interactions entre ces ressources.

Mots-clés : Conservation de l'environnement agricole; Lien entre eau-alimentation-énergie; Plateforme NEWS; Évaluation de programme agricole.

INTRODUCTION

Many of the most likely and influential global risk factors presented by Global Risks 2023 are related to climate change, water security and food security. To cope with such changes in the future environment, it is necessary to secure and utilize limited resources sustainably. Also, the demand for food is increasing with population growth and economic growth, and it is predicted that disasters and climate variability due to climate change will increase in the future. In the 'Agricultural Innovation, Productivity, and Sustainability Report in Korea,' the OECD makes various policy recommendations for achieving sustainable agriculture and agricultural innovation through analysis of agricultural conditions and policies in Korea. As one of the solutions to this perception, policy alternatives related to resources management for achieving sustainability emerged in 'Managing the Water-Energy-Land-Food Nexus in Korea.'

Agricultural activities are negatively impacting the rural environment during crop cultivation. Crop cultivation activities accompany the degradation of rural environmental resources, including tillage, chemical application, nutrient supply, and water consumption. The Ministry of Agriculture, Food and Rural Affairs (MAFRA) of South Korea has implemented the Agricultural Environment Conservation Program (AECP) to conserve natural resources and landscapes in rural areas. The AECP involves two activity folds: village-level and farmer-level activities. Each category includes conservation activities related to the agricultural environment. The AECP includes 5 categories: soil, water, landscape, atmosphere, and heritage & ecology. The soil category includes nutrient management, soil erosion prevention, pesticide reduction, and related activities. The water category includes water quality improvement, non-point pollution source management, agricultural water conservation, etc., and the atmosphere category includes greenhouse gas reduction, axonal odor reduction, etc. The heritage and ecology category include enhancing biodiversity and conserving ecosystems, among other activities. In this study, activities from the soil, ecology, atmosphere, and water categories are selected for quantitative evaluation. The AECP program is a direct payment program to which participants are eligible, and MAFRA has to evaluate the effectiveness of AECP in terms of environmental and economic benefits.

Water-Energy-Food Nexus interprets water-energy-food interrelations to achieve efficient use of resources and ultimately to the sustainability of agriculture (Choi, 2017). Sustainable water resource management using WEF Nexus can increase the sustainability of available water resources by using balanced water resources between water, food and energy. There is a trade-off relationship among input resources such as energy, water and cost, for increasing food productivity, therefore, it is necessary to analyze the relationships comprehensively rather than single resource analysis (Bassel & Rabi, 2015). Using Water-Energy-Food Nexus, the evaluation of the sustainability of water, energy, and food resources could be conducted by applying various scenarios and analyzing the trade-off between resources.

This study presents research cases in which the water-food-energy nexus was applied in South Korea to analyze the relationship between agricultural resources and to establish and develop a platform using the results of nexus analysis. As concerns about the environmental load in the agricultural sector have increased, a platform for evaluating the impact of cultivation activities on agricultural resources using the water-food-energy-carbon-water quality nexus considering the effect on environmental load is established. NEWS (The Nexus Environmental Working for Sustainability) defined the relationship between various cultivation activities included in the AECP (Agricultural Environment Conservation Program) and agricultural resources and quantitatively analyzed the impact of cultivation activities such as water management, fertilizer management, tillage management, and conservation practices.

METHODS

AECP and study area of AECP

AECP (Agricultural Environment Conservation Program) is consists of several parts, soil, water, atmosphere, landscape and life, heritage and ecology parts. The purpose of the soil part is 'nutrient management/ soil erosion prevention' and the purpose of the water part is 'water quality improvement and agricultural water conservation', the purpose of the atmosphere part is 'greenhouse gas reduction'. In addition, AECP is divided two parts, individual activities and joint activities. Cultivation activity scenarios using AECP consisted of water management, fertilizer management, tillage management, conservation practices, and other activities, and each part included related cultivation activities mainly performed in paddy and open-field.

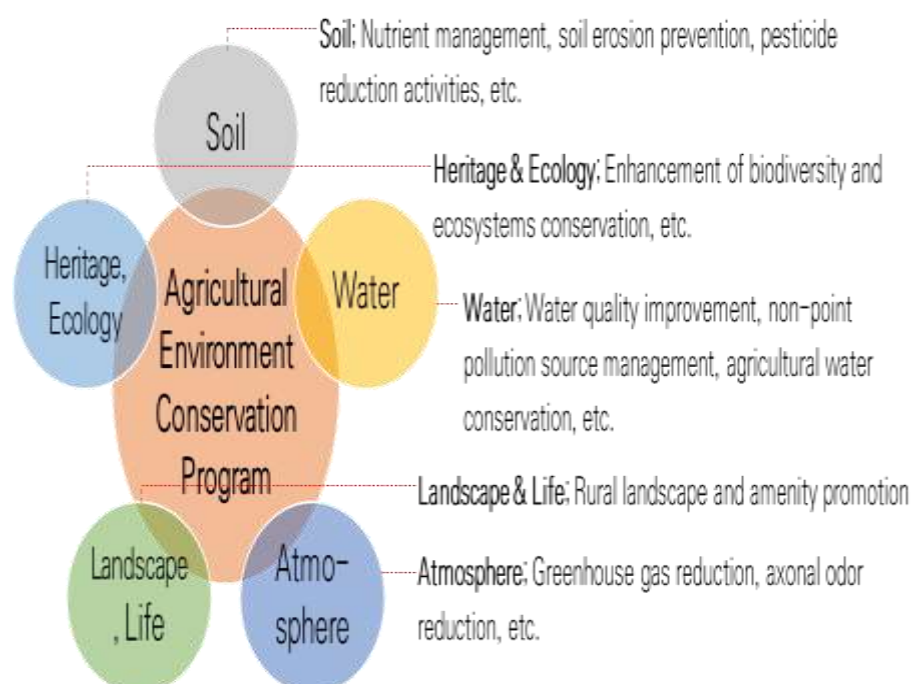


Figure 1. The agricultural activities of AECP

The study area is Mundang-ri, Dosan 2-ri village located in Hongseung-gun, Chungcheong nam-do, one of the villages participating in the AECP project. Table 1 shows the participation status about some of the agricultural activities by parts of the AECP. It has AECP 9 activities related to soil, ecology, atmosphere and water.

Table 1. AECp participation status in Hongseung-gun

Part	Activities	Period (month)	Partici-pants (person)	Areas (a)
Soil 1-2	Using of slow-release fertilizers	4-5	1	86.4
Soil 2-1	Returning agricultural by-products to paddy, fields	10-11	84	7075.6
Soil 2-2	Cultivation of green manure crops and soil return during fallow period	11-12	36	1,625
Soil 3-1	Covering sloping field with rice straw	-	-	-
Ecology 1-1	Preventing pests as natural enemies	5-10	2	185.3
Ecology 1-2	Get rid of weeds without herbicides	5-10	67	2641.4
Atmosphere 1-1	Minimizing tillage	4-5	43	2806.5
Atmosphere 2-1	Using microbial agents to reduce livestock odors	4-12	6	23.1
Water 2-1	Controlling drainage levee and agricultural water management	-	-	-
Total		-	241	14,559

Water-Energy-Food-Carbon-Water quality Nexus under agricultural cultivation activities

Agricultural cultivation activities such as irrigation, fertilization, tillage, and conservation practices of AECp have a significant impact on water, energy, food resources, carbon emissions, and water quality. In addition, the nexus elements affected by cultivation activity are different, and the influence of external conditions and cultivation activities could act simultaneously. Therefore, the water-energy-food-carbon-water quality Nexus under agricultural cultivation activities was defined as follow (Figure 2) using integrated system dynamics. Cultivation activity scenarios consisted of water management, fertilizer management, tillage management, conservation practices, and other activities, and each part included related cultivation activities mainly performed in paddy and open-field. In the future study, as in the case study above, nexus elements under agricultural cultivation activities would be simulated, and the relationship between cultivation activities and agricultural resources would be analyzed and quantified.

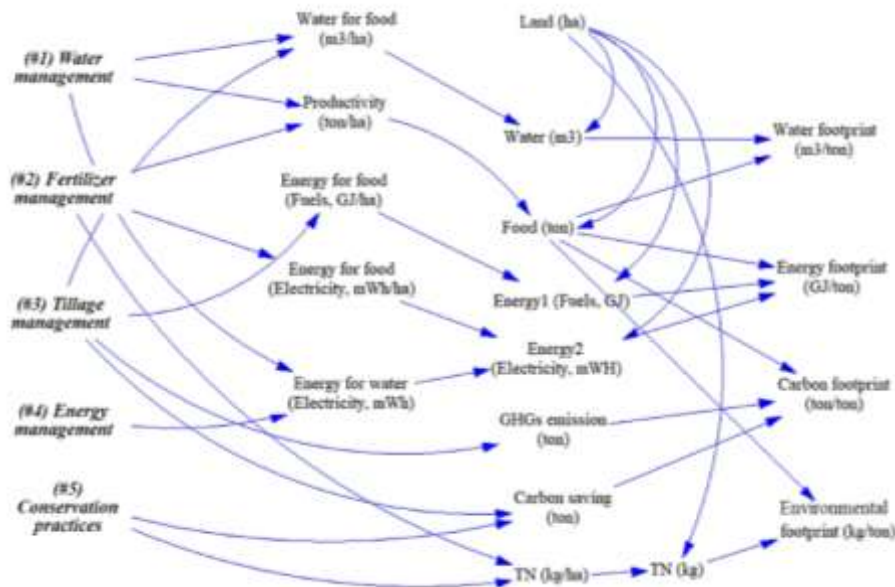


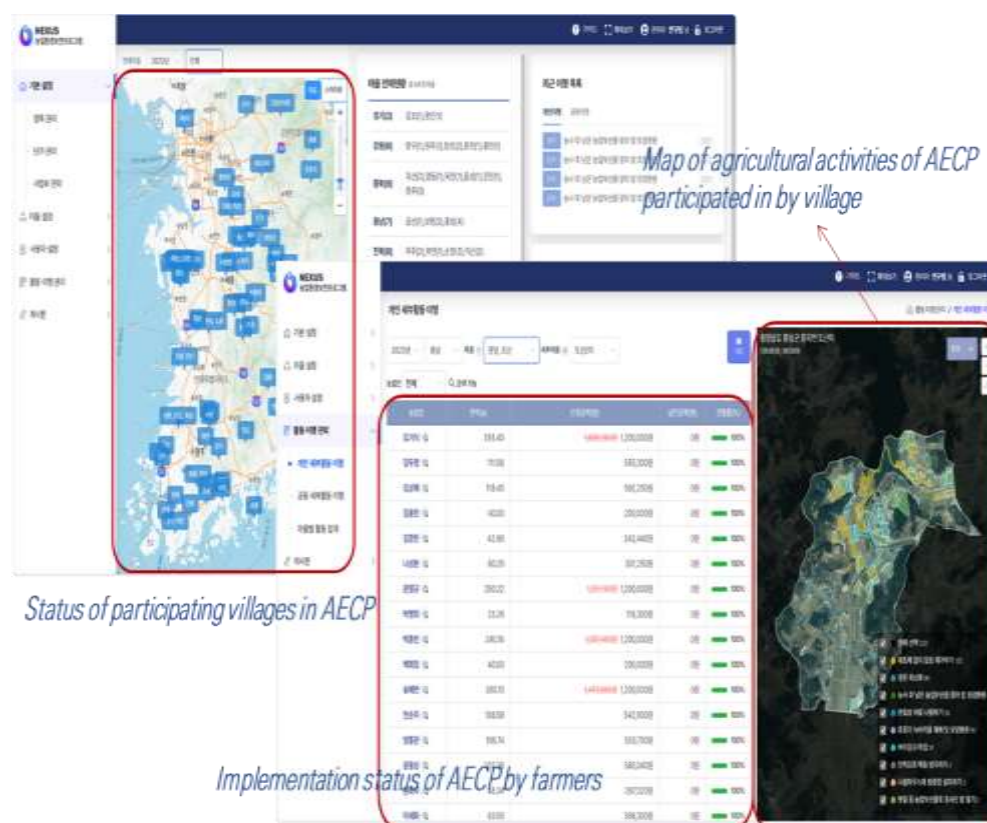
Figure 2. Linkage between water-energy-food-carbon-water quality nexus resources under agricultural cultivation activities

RESULTS AND DISCUSSION

The following Fig. 3 shows the screen composition of the NEWS platform. The platform is currently under development and can analyze and evaluate the impact of agricultural activities related to cultivation on agricultural resources such as water, food and energy, as well as carbon emissions and water quality. Representative scenarios are presented as water management, fertilizer management, tillage management, and conservation practices scenarios, and users can define and compare changes by nexus elements before and after activities. As shown in the radial graph below, the rate of change before and after agricultural activities is shown for water, food, energy, carbon storage, carbon emission, and water quality, which can be indexed and compared.

It is possible to quantitatively analyze the impact of various agricultural activities of the AECP described above, and it can be used for quantitative evaluation of villages participating in AECP and selection of participating villages. Using this NEWS platform, AECP activities in the village involved are monitored and activities impacts are evaluated using model and scenario based. Figure 3 shows the locations of villages participating AECP, detailed land use and soil maps are also based on the GIS. The platform utilizing APEX model presents the analysed results using inputs from the village activities and scenarios. The results presents with radar charts to help understanding of the impact of the activities in terms of water quality and environmental effect and benefit. The graphical display of the platform can help the stakeholders including farmers, consulting firm staffs and governmental officers to evaluated the impacts of AECP activities of the participating villages.

The reporting function of the platform including detail information of program can assist governmental officers to implement the AECP policy and qualified results of AECP effectiveness and improvements of the environment due to the AECP activities also can assist the policy decision of the AECP policy in terms of budget effectiveness and preparation.



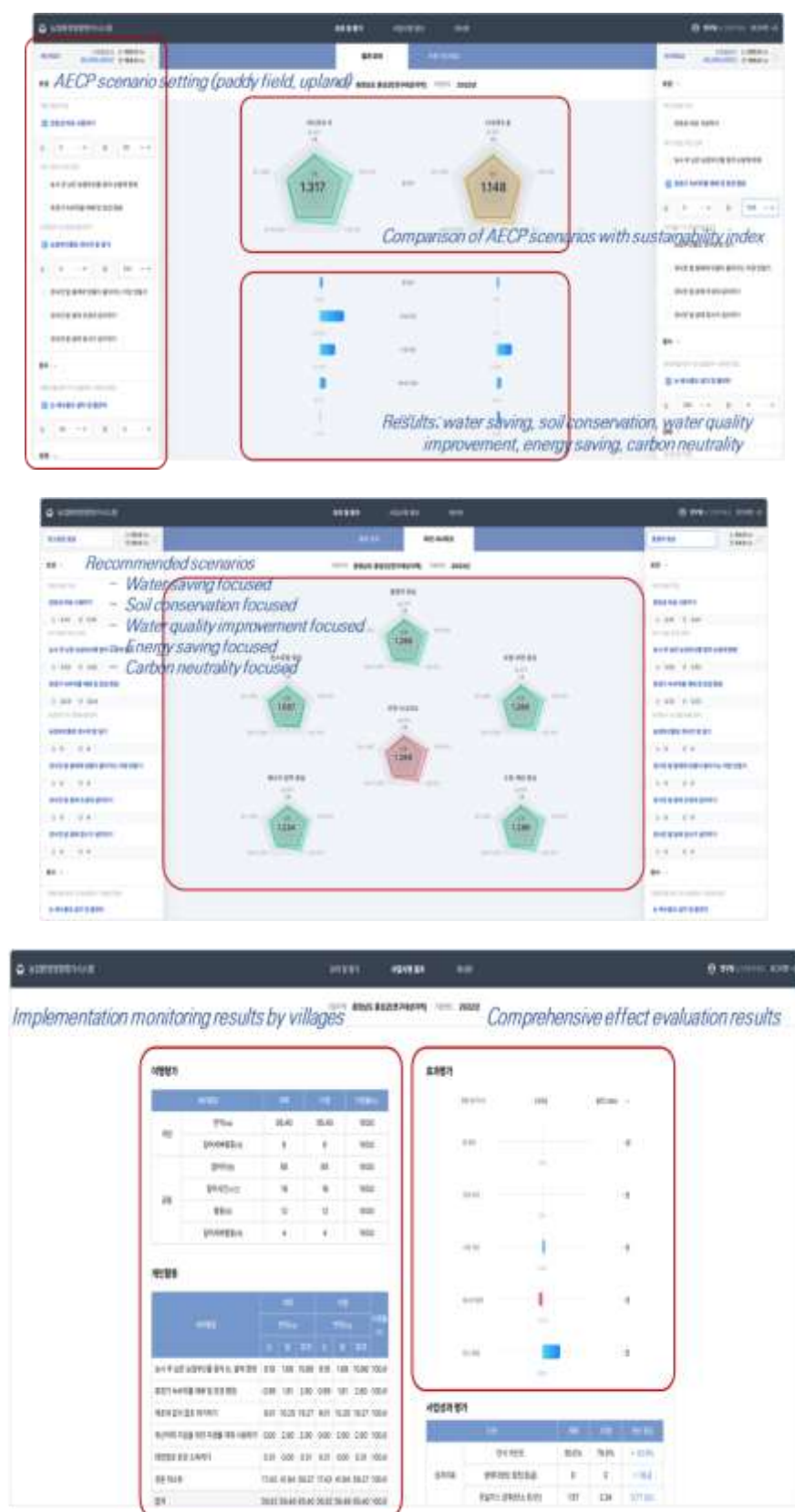


Figure 3. NEWS (The Nexus Environmental Working for Sustainability) platform

CONCLUSIONS

Crop cultivation activities accompany the degradation of rural environmental resources, including tillage, chemical application, nutrient supply, and water consumption. The Ministry of Agriculture, Food and Rural Affairs (MAFRA) of South Korea has implemented the Agricultural Environment Conservation Program (AECF) to conserve natural resources and landscapes in rural areas. To prevent and mitigate negative impacts of agricultural activities to the rural environment during crop cultivation, the nexus platform was developed to evaluate the AECF activities. The AECF involves two activity folds: village-level and farmer-level activities. Each category includes conservation activities related to the agricultural environment. The platform involves database, GIS, APEX model analysis system and graphical user interface including menus and results presentation. The nexus system, NEWS (Nexus Environment Working for Sustainability) was developed and presented.

The results of this study are presenting cases in which the water-food-energy nexus was applied in South Korea to analyze the relationship between agricultural resources and to establish and develop a platform (NEWS) using the results of nexus analysis. Therefore, the basic data about agricultural resources and selected pilot sites were collected, and scenarios of agricultural cultivation activities were constructed. In addition, the nexus system under various scenarios was defined. Nexus analysis is carried out by evaluating resources use and environmental impacts and comparing between the standardization results of scenarios. Using the results of each nexus element, NEWS, nexus platforms, were developed. Using this platform, users including farmers, consulting firms and government officers can define scenarios and simulate nexus elements such as agricultural resources, carbon, and water quality according to the various scenarios. In addition, it can be used in decision-making by considering economic factors and sustainability index. The platform including detail information of program can assist governmental officers to implement the AECF policy and qualified results of AECF effectiveness and improvements of the environment due to the AECF activities also can assist the policy decision of the AECF policy in terms of budget effectiveness and preparation. As such, the water-food-energy nexus studies are expected to be used as fundamental data to support a policy decision-making tool by comprehensively analysing and quantitatively evaluating the impact of climate change and agricultural cultivation activities on resources and between resources.

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