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Dear Editor and reviewers

We appreciate your comments and tried to apply all comments to the revised manuscript. The main comments seemed to be related to the validation of methodology and contribution of this study.

First, we validated the methodology using observed data and added a new chapter "**3.3 Validation of rice distribution simulation compared to 2016 observation**". Second, we mentioned the application and contribution of this study in this chapter, for example, the importance of local distribution of food in the countries where produce large amount of domestic food products.

However, there were still limitations of validation in a scale issue and application of international trade issue, thus, we added more explanation of limitations in this study to the new chapter "**4. Limitations, but possibilities**". We also added more analysis of regional flows of rice and assessed the impacts of local food security on the regional dependency of rice in "**3.2 Analysis of impacts of food security in prefectures on the entire rice distribution through various SSR scenarios**" with additional Figure 2.

To sum up, we added 1) Validation of methodology using regional data, 2) Limitations and contribution, and 3) Addition analysis of regional dependency of rice flow in revision.

Please find the more details in revision notes.

All authors including myself have seen and approved this revised manuscript.

I am looking forward to your response.

Thanks.

Sincerely yours.

Sang-Hyun Lee

Detailed review: Reviewer #2

1. Major Comments

Reviewer's comments	(1) the methodologies are not novel (2) the study and its conclusions do not have an international scope.
Response	<p>➔ The main objectives of this study is to analyze the impacts of local food security in local distribution of food in Japan using gravity model. However, the details of local distribution of food including origins and destinations were not available, thus we set the potential situation and followed the theoretical methodology. In addition, we applied the various local food security scenarios and assessed the impacts of local food security on local distribution of rice. In particular, we calculated the internal virtual water trade through local distribution of rice and emphasized the importance of dependency of food on other regional water resources in terms of resource governance and integrated water-food management.</p> <p>➔ However, in previous manuscript, there was lack of explanation relating to reviewer's comments such as novelty and international scope. Therefore, we added more explanations and opinions about application and contribution of this study in new chapter "4. Limitations and possibilities".</p>
Page 10 Line 387 - Page 11 Line 407	<p>4. Limitations, but possibilities</p> <p>Although this study focused on Japanese cases, it could be universal with cases in the countries including large amounts of domestic transportation of food products. Various studies showed the influence of the international food trade on food security and resource management. However, it is hard to apply the international food or virtual water trade to national or local resource management. In addition, the domestic distribution of food products is more directly related to resource management, such as water, land, and energy. Concerning governance and integrated water-food management, it is important to analyze the local distribution of food among prefectures and assess the impacts of local food security in each prefecture on integrated water-food management. The methodology in this study assumed the potential situation of local distribution of rice and applied several scenarios related to local food security with potential impacts of distances using the gravity model. We believe it could show various possibilities, and the outcomes could be used as a guideline for integrated national-regional-local food and water management.</p> <p>However, there are limitations in methodology, validation, and application. First, the gravity model is a traditional model in economic research, and its usage could not be regarded as the innovation of methodology. However, the approach, based on the gravity model in this study, could analyze the distribution of local food considering local food security policy and distance between prefectures. For example, we applied different self-supply in each prefecture as SSR scenarios, which represent local food security policy. In addition, international trade, population, and climate change could affect production and consumption at prefectures. Therefore, we could assess the impacts of them on local food distribution through the methodology in this study. However, the simulation included complex network of 47 prefectures, and the gravity model hardly derives accurate results from single simulation. Therefore, we set observed total production and consumption in each prefecture as the control factors, and several iterations shown in Eq. (6) were conducted until the simulated values were close to the control factors in order to reduce the bias and error of simulation.</p>

	<p>Page 11 Line 433</p> <p>—</p> <p>Page 12 Line 454</p>	<p>Regarding application and contribution, this study focused on the domestic distribution of rice in Japan, and it seems to be an exclusive case study with little application to international cases. Many studies relating to international food trade or water security focused more on the interlinkage between countries rather than downscaled impacts on local or regional areas. In particular, many studies targeted countries that have water-scarce but less food security or global area. However, Asian countries—such as Thailand, Taiwan, Vietnam, Japan, and S. Korea—are producing a lot of rice for domestic consumption with large amounts of irrigation water supply. They also have high levels of self-sufficiency of rice, thus local distribution of rice could be an important factor for managing local-regional-national food and irrigation water. In addition, resource governance or integrated resource management could be considered a way of sustainable management, and the distribution of domestic food could be more feasible than international trade concerning resource governance. Even if great deals of food products are traded between countries, it is difficult to apply integrated water-food management that include countries, because water-food are highly dependent upon spatial characteristics and boundaries of management, as well as local government. However, local policy of food security or water management could relate to production in other local areas. Accordingly, we need to analyze the food transportation between local areas and water-food dependency on other local areas. In addition, it is important to understand the gap between the national food policy and local situation, especially in the countries where domestic production occupies a large proportion of food security.</p> <p>This study analyzed internal virtual water trade through local distribution of rice to emphasize the impacts of food dependency to other prefectures on regional water resources. In this study, the flows of virtual water between prefectures and regions were mainly considered, rather than total water withdrawal or total production of rice. In other words, we focused more on how the local distribution of rice could affect regional water security through internal virtual water flows in Japan. In sum, the resource governance or integrated resource management would be more feasible on a local or regional scale, rather than international one, and local distribution of food and internal virtual water flows could be important factors for water-food management within an integrated local-regional boundary.</p>
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Reviewer's comments	(1) The water withdrawals figures are provided by the local ministry. The distribution numbers however are completely based on the gravity model, without any form of validation. Therefore it remains a bit unclear whether or not the presented numbers are valid. Especially since the gravity model depends on an empirical parameter (α), which the authors set to 2. Explaining this choice could help increase readers confidence.
Response	<p>➔ We tried to apply reviewer's comments about methodology of gravity model in this study. In particular, we added some paragraph about the friction parameter and validation of model.</p> <p>Please find the additional paragraph.</p>
<p>Page 8 Line 313 — Page 9 Line 334</p>	<p>3.3 Validation of rice distribution simulation compared to 2016 observation</p> <p>To validate the food distribution model, we compared simulated results to observed data. Regarding rice distribution, the Japanese government provided the regional self-dependency data in 2016, as shown in Figure 5. In the case of the Tohoku region, a representative rice paddy area, the 2016 observation data showed that 79.6 % of total rice consumed in the region was provided from prefectures in its own region. However, the regional self-dependency was calculated at 46.3% in the non-weighted distribution under the 20% SSR scenario. On the contrary, in cases of weighted distribution under the 20 % SSR scenario, regional self-dependency in the Tohoku region was 83.4%. This was only a 4% difference from the observation data in 2016. In most regions, except for Kansai, the simulation of regional self-dependency through the weighted distribution was closer to observation compared to non-weighted distribution. Therefore, the weighted distribution considering the distance between prefectures in gravity model could be more suitable for analyzing internal trade of rice among prefectures.</p> <p>However, the Shikoku region showed a large difference between simulation and observation under the 20% SSR scenarios. Even the regional self-dependency in the Shikoku region, through the weighted distribution under the 20% SSR, was calculated to 41.9%, but it was still largely different from the observation (77.3%). The Shikoku region is a big island, and it is quite limited regarding access to other regions. This is because only three bridges are connected to the Hiroshima, Okayama, and Hyogo prefectures. Therefore, we believe the regional self-dependency of rice was higher than simulation under 20% SSR scenarios. Accordingly, we compared the observation with simulation considering 4% and 60 % SSR scenarios, and we found that the increase of SSR from 20% to 40% in all prefectures could give a more accurate simulation, especially in the Shikoku and Chugoku regions. Despite only using the regional self-dependency as observation data to validate the model, we found that the weighted distribution could simulate results that are more feasible rather than a non-weighted one. In addition, it is hard to define the accurate SSR scenario, but the food distribution model in this study could assess the various situations relating to local food security through the adaptation of various SSR scenarios.</p> <p>Figure 5 The proportion of consumption of rice produced in own region in total consumption.</p>
<p>Page 11 Line 408 — Page 11 Line 417</p>	<p>The validation is the most important process for applying the gravity model to the real world. In particular, the friction parameter (α) in the model should be decided through the validation process. However, it is difficult to get the data about local distribution of products, including details of origins and destinations. In Japan, the details about the transportation of rice among prefectures were not available, but the local distribution of rice should be an important factor for water-food governance and integrated resource management. Accordingly, we applied several friction parameters from 1.0 to 2.0 increased by 0.1 and realized the friction parameter from 1.0 to 2.0 did not bring big changes in results. This is because the</p>

		variance of distance between prefectures in Japan might be regarded as small in value compared with international trade. Thus, we applied 2.0 as the friction parameter to emphasize the influence of distance on local trade as a potential scenario. In addition, we tried to reduce the bias and validate the simulation through comparing the simulated results with limited observation, which was a regional scale of data about the self-dependency of consumed rice in each region.
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Reviewer's comments	(2) Another issue is the absence of the influence of foreign exports to/from Japan, since 10% of the domestic consumptions originates abroad. Discussing what the effect of this might be on the results would help.
Response	<p>→ We agree that international trade could be also an important factor for local distribution in this study. However, the international trade is related to a very complex network and situations rather than domestic distribution. In addition, this study focused on domestic boundary for analyzing local dependency on food and its impacts on regional water management in terms of water-food governance. Thus, we added some paragraph relating to reviewer's comments.</p> <p>Please find the additional paragraph.</p>
Page 11 Line 418 - Page 11 Line 432	<p>In this study, we only consider domestic production of rice, which occupied about 90% of total consumption, and the export and import totals of rice were applied as fixed values. We agreed that the changes in international trade could affect domestic production, which represents market size in the gravity model in this study. However, only national data, such as total import or export of rice in Japan, were available; thus, it was difficult to identify how much rice was imported (or exported) from (or to) each prefecture. Although this study focused on domestic trade of rice with non-changed international trade, the approach based on the gravity model could adapt to the changes in international trade. For example, more food self-sufficiency in Japan, as a national policy, would encourage an increase in domestic production, and market size of production would be increased. Furthermore, the decrease of paddy fields could cause less domestic production, and Japan would increase importing rice from other countries. Thus, the changes in international trade could have relationships with production within the gravity model, and the impacts of international trade on local food distribution could be assessed. However, we need to decide which prefectures have more increases rather than other prefectures, even though the amount of international imports and exports could be quantified. In other words, the international trade part relates to various situations and variables—including national and local food security and domestic production changes, as well as the international trade network. Therefore, we thought it was beyond the study boundary and reserved it for another future research topic that could possibly use the methodology in this study.</p>

2. Technical corrections

Reviewer's comments	<p>Line 30: Please define self-sufficiency. I'm assuming it is something like "rice consumed/rice produced", but it would be good to specify that.</p> <p>Line 53: Change ". . .also be to related water management. . ." to ". . .also be related to water management".</p> <p>Paragraph starting on Line 53: break this paragraph into three shorter ones.</p> <p>Line 109: Give a reference for this claim.</p> <p>Line 130: Alpha is defined twice.</p> <p>Line 139: Definition here of AE and RI is different from the ones on line 129.</p> <p>Line 181: Table 1 should be Table 2.</p> <p>Line 182: The number here does not add up to the numbers in table 2, should be 51.5</p>
Response	<p>➔ We applied all technical corrections. Please find the revised manuscript</p>