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Expert assessment on agri-food implications of March 2011 earthquake, tsunami and Fukushima nuclear accident in Japan[1]

Hrabrin Bachev[2]

Introduction

On March 11, 2011 the strongest recorded in Japan earthquake occurred which triggered a powerful tsunami and caused a nuclear accident in one of the world's largest nuclear plant - Fukushima Daichi Nuclear Plant Station.

The triple 2011 disaster has had immense impacts on people life, health and property, social infrastructure and economy, agricultural and food production, distribution and consumption, natural and institutional environment, etc. in North-eastern Japan and beyond. We have already presented the assessment of multiple impacts of the earthquake, tsunami and nuclear accident on socio-economic life, agri-food sector, and natural environment in our previous publications (Bachev, 2014, 2015; Bachev and Ito, 2013).

Our previous analysis has demonstrated that some of the impacts and factors of the March 2011 disasters are difficult to identify and assess due to the insufficient information, controversial data, continuing challenges and uncertainties, etc. In order to expend the assessments we have carried out numerous in-depth interviews with leading experts in the areas, and representatives of governments, farmers, food industry and non-governmental organizations, and affected farmers, business and consumers.

In addition, we have organized two expert assessments in order to identify the 2011 disasters' short and longer terms impacts on agriculture, food industries and consumers as well as factors for persistence of negative impacts, and longer-term impacts on major resources, productions, organizations, efficiency, etc. in the most affected regions and the rest of Japan.

The experts' identification was based on a careful study of their positions in the affected agri-food chains, decision-making, and post-disaster evaluation and governance as well as research, publications and presentations. In addition, multiple consultations with the leading analysts in the field were made before selecting the members of the expert panels.

The experts were asked to specify the overall impacts on agriculture, food industry, and food consumption in different regions affected by the earthquake, tsunami and nuclear disaster. Since individual effects have quite different time span and the individual experts have quite different horizon we let the experts to decide on the duration of "short-term" and "longer term".

We prepared a list of factors for persistence of the negative effects on the base of an extensive study of most commonly cited factors by officials, experts, stakeholders, analysts, media, etc. A similar approach was employed in working out the list of most likely affected in

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the long-term aspects of agri-food sectors (resources, performances, behavior, markets, costs, governance, international trade, etc.). There was also an option left for experts to include other (new) factors and assess their importance as well as a space for free comments related to the 2011 disasters. A Japanese translation of the assessment form was provided to all experts who are not fluent in English, while a bilingual expert translated responses back into English.

The first expertise was carried out in June-July 2013 and focused on the specific impacts and factors of the Fukushima nuclear accident. The number of experts was eleven, including four researchers (two from the Fukushima University, one from the Tohoku University, and one from the Tsukuba University), two representatives of the prefectural government in Fukushima, two farmers, two representative of farmers associations from Fukushima prefecture, and one representative of a Fukushima food industry organization. One out of the twelve initially selected expert panel members[3] did not fill in the assessment form but gave us an in-depth interview on major issues.

The second expert assessment was carried out in October-November 2014 and covered the specific and combined impacts of the March 2011 earthquake, tsunami and nuclear disaster. The number of experts was thirteen – all leading researchers in the area[4] (five from the Tohoku University, one from the Tsukuba University, and seven from the Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries). The same approach like in the first expertise was used throughout that assessment.

This paper presents the results of the experts' assessments on socio-economic impacts of the March 2011 earthquake, tsunami and the Fukushima nuclear disaster on the Japanese agriculture and food sector. Nearly four years after the triple disaster, that expertise gives some tentative assessment on the diverse (specific, combined, short-term, long-term, functional) impacts of the 2011 earthquake, tsunami and nuclear accident on agriculture, food industries, and food consumption in different regions of the country.

1. Specific impacts of earthquake

1.1. Short-term implications

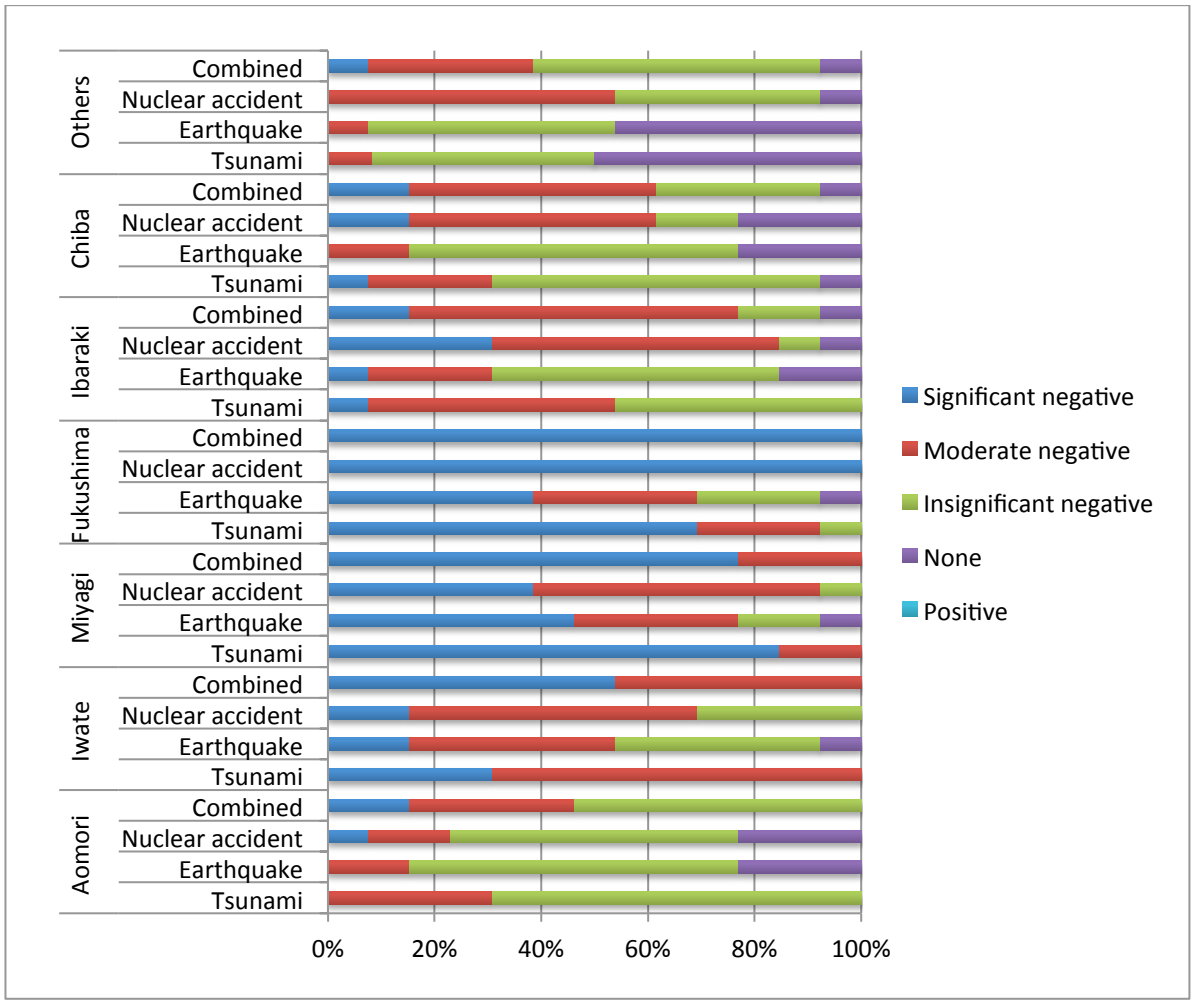
According to the experts, the short and long-term impacts of the Great East Japan earthquake on agriculture, food industries and food consumption in different regions of the country have been quite different.

The specific short-term impact of the earthquake on agriculture in Miyagi and Fukushima prefectures is significant negative according to a greatest proportion of the experts (Figure 1). Furthermore, a good portion of them evaluates that impact as moderate negative. In Iwate prefecture the most of the experts believe that impact is moderate or insignificant negative, while in Aomori, Chiba and Ibaraki prefectures the effect is predominately assessed as insignificant negative. The specific short-term impact of the earthquake on agriculture in other parts of the country is generally evaluated either as insignificant or none.

[3] the Managing Director of the Consumer Cooperatives Union, Fukushima.

[4] All of them assessed the impacts on agriculture, eleven assessed the impact on food industry, and twelve assessed the impact on food consumption.

Figure 1. Short-term impacts of March 2011 disasters on agriculture in different prefectures of Japan



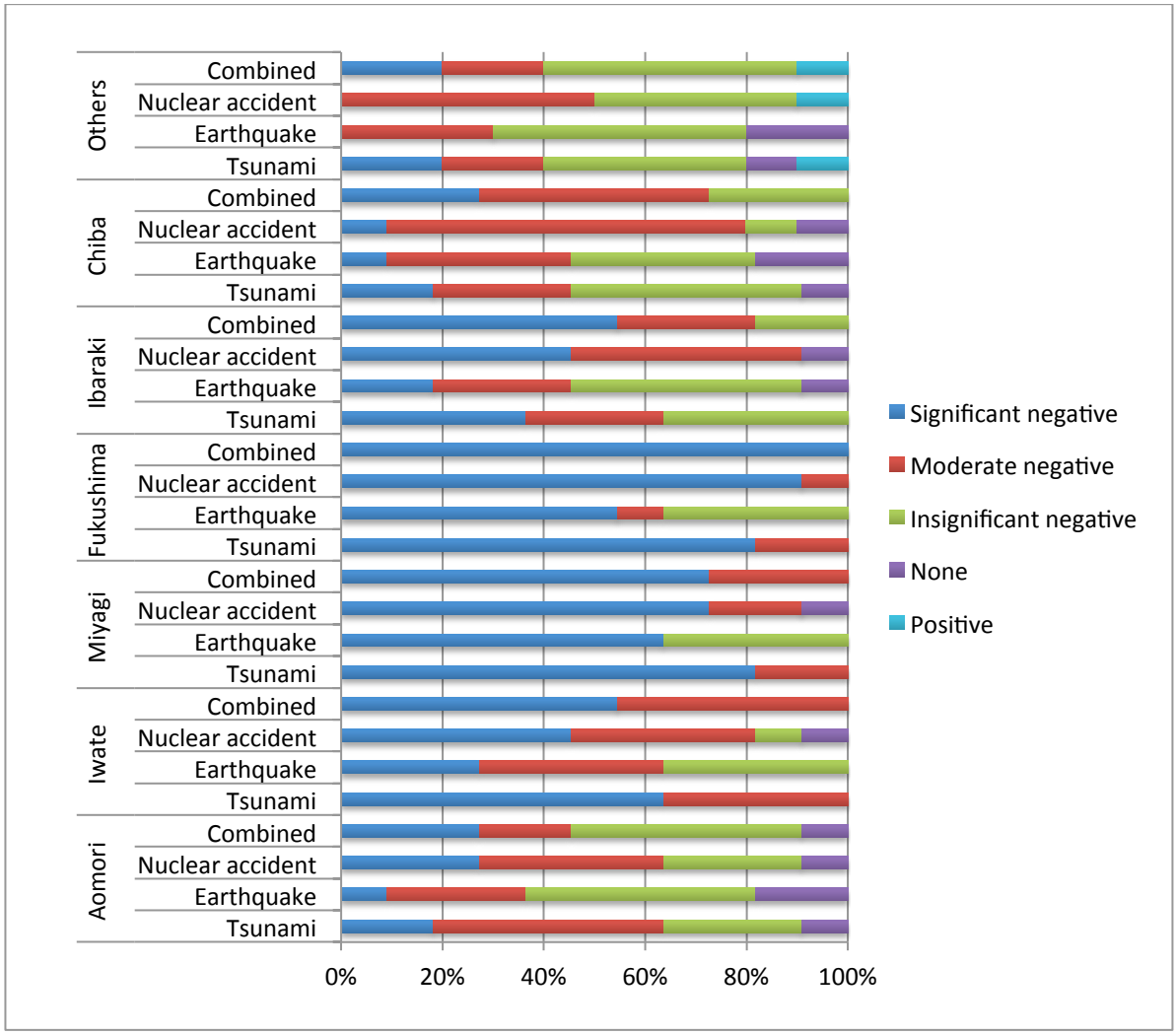
Source: assessment by panel of experts, 2014

At the same time no expert believes there is a positive specific of combined short or long-term impact on the 2011 disasters on agriculture in Japan.

The specific short-term impact of the earthquake on food industries in Miyagi and Fukushima prefectures is significant negative (Figure 2). Nevertheless, a good segment of the expert panel evaluates that impact as insignificant negative. In Iwate and Chiba prefectures the greatest portion of the experts assess that effect as moderate negative or insignificant negative. The short-term impact of the earthquake on food industries in Aomori and Ibaraki prefectures, and the rest Japan is predominately evaluated as insignificant negative. However, many experts also believe the later impact is more severe (including up to a significant one in the two Tohoku prefectures).

Simultaneously, no expert indicates that there is a positive specific short or long-term impact on the 2011 earthquake on food industries in Japan.

Figure 2. Short-term impacts of March 2011 disasters on food industries in different prefectures of Japan

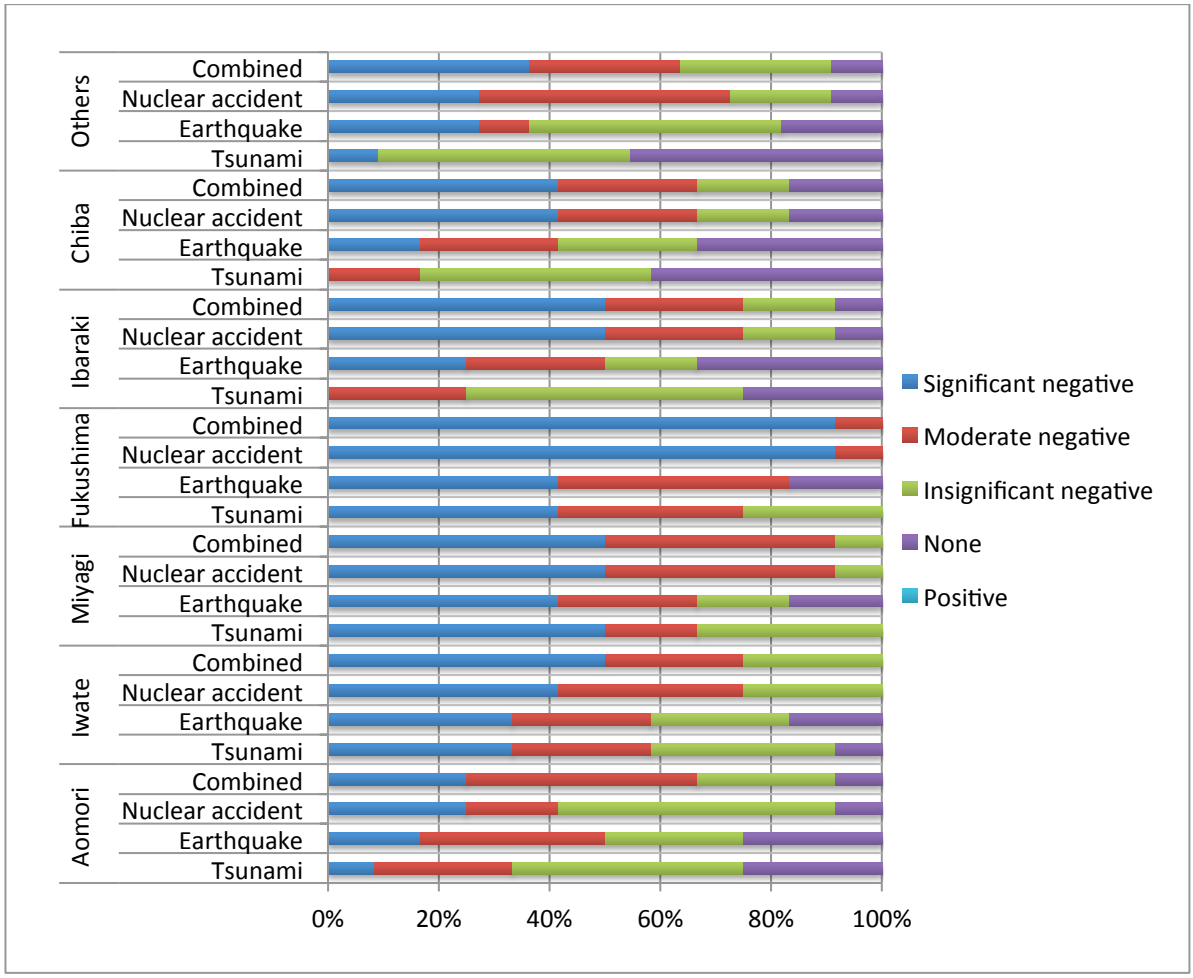


Source: assessment by panel of experts, 2014

The majority of experts think that the specific short-term impact of the earthquake on food consumption in Fukushima, Miyagi and Iwate prefectures has been significant or moderate negative (Figure 3). Despite that, the number of those evaluating that impact as insignificant or none is also not small. For Aomori and Ibaraki prefectures, a half of the experts evaluate that impact as significant or moderate negative while another half as insignificant negative or none. The specific short-term impact of the earthquake on food consumption in Chiba prefecture is mostly assessed as insignificant negative or none, but a good proportion also ranks it with a higher magnitude. In the rest of the country that impact is mostly estimated as insignificant, but every third expert still believes it is more severe (predominately significant).

No expert believes there is a positive specific or combined short or long-term impact of the 2011 disasters on food consumption in Japan.

Figure 3. Short-term impacts of March 2011 disasters on food consumption in different prefectures of Japan

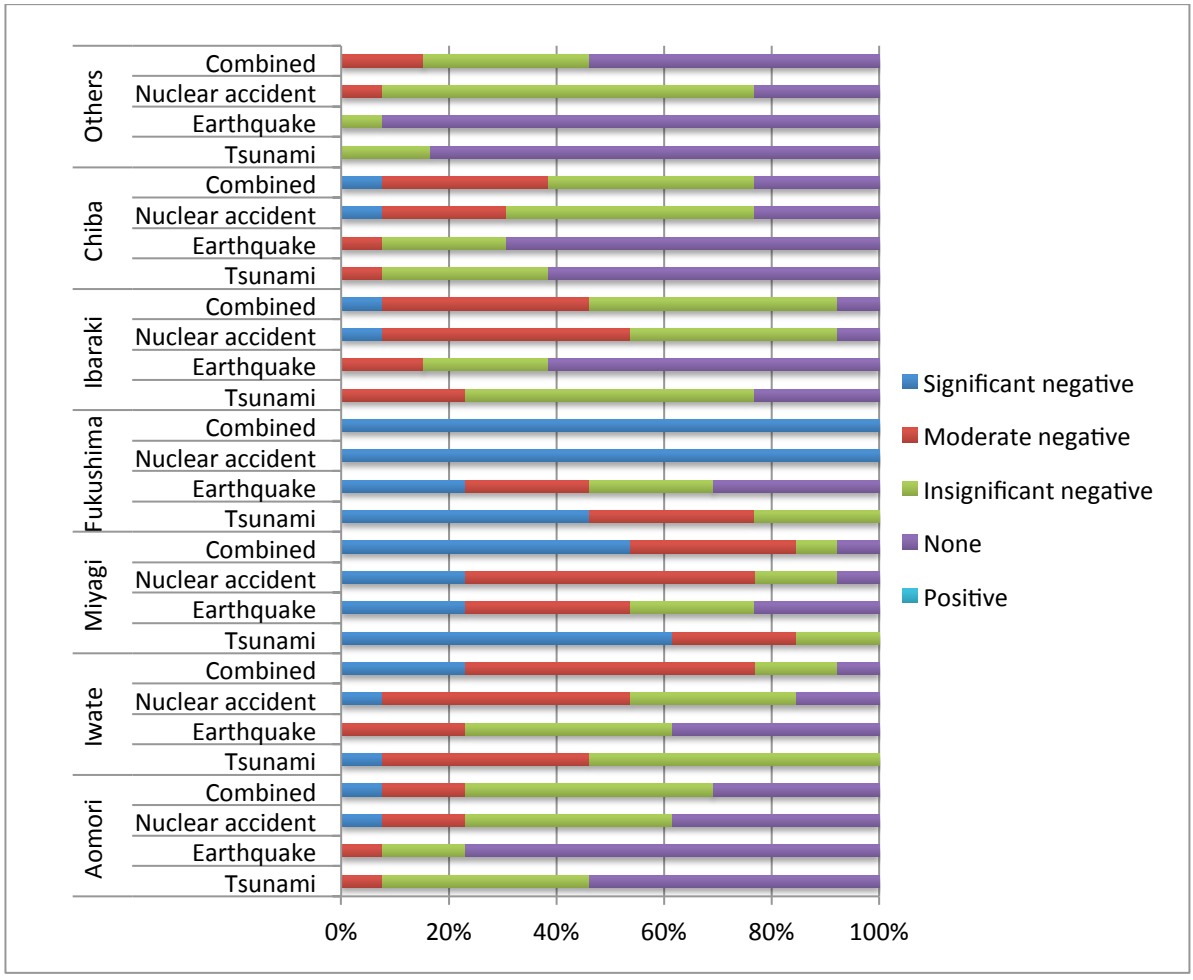


Source: assessment by panel of experts, 2014

1.2. Long-term implications

According to a great majority of the experts there will be no specific long-term impact of the 2011 earthquake on agriculture in Aomori, Ibaraki and Chiba prefectures, and other parts of Japan (Figure 4). Nevertheless, a good number of experts expect more severe consequences for the later three Tohoku prefectures (mostly evaluated as insignificant). The experts are divided in their impact estimates for Miyagi and Fukushima prefectures as around a half foresees it as significant or moderate negative, while the rest as insignificant negative or none. Long-term consequences for Iwate agriculture are predominately seeing as negative (mostly insignificant) but a significant number of the experts also expect no impact at all.

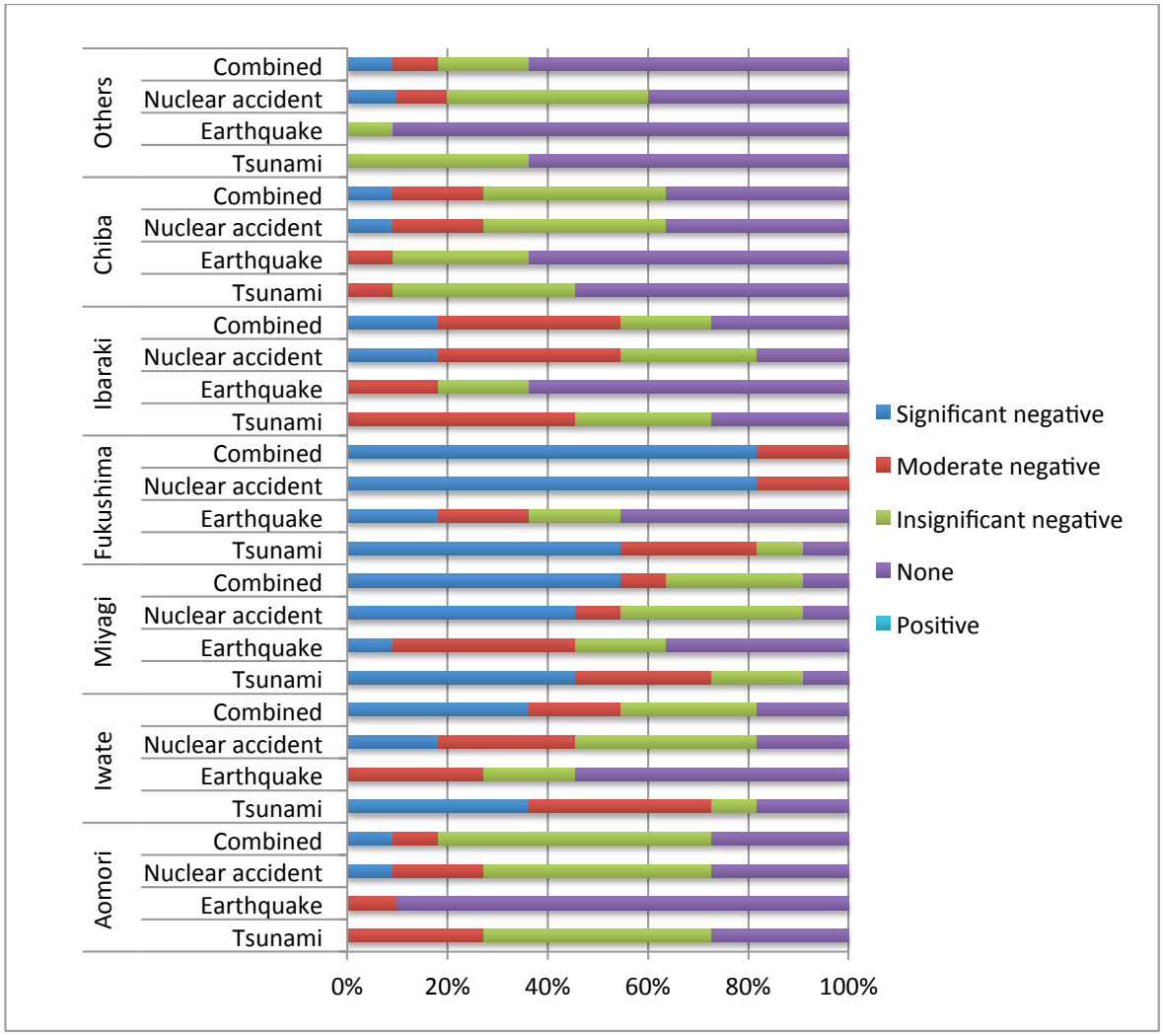
Figure 4. Long-term impacts of March 2011 disasters on agriculture in different prefectures of Japan



Source: assessment by panel of experts, 2014

The bulk of experts estimate there will be no specific long-term impact of the earthquake on food industries in Aomori, Iwate, Ibaraki, and Chiba prefectures, and other parts of Japan (Figure 5). Nevertheless, a good proportion of the panel foresee some insignificant to moderate adverse long-term consequences for Iwate and Ibaraki prefectures' food industries. In Miyagi and Fukushima prefectures most experts expect some negative long-term impact predominately evaluated as moderate and insignificant in the former one and not consensually determined for the later. However, the number of experts anticipating no impact in the later two prefectures is also considerable.

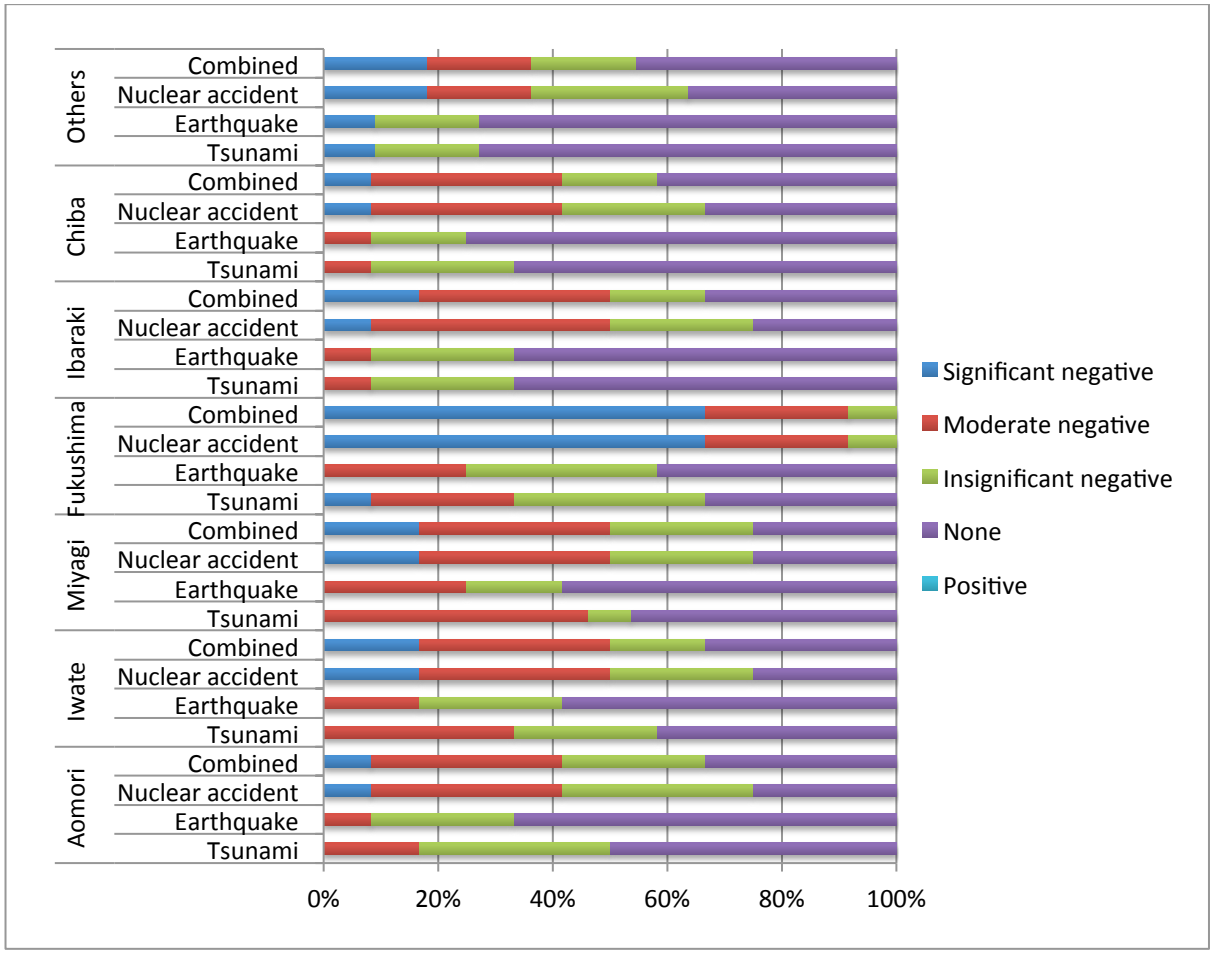
Figure 5. Long-term impacts of March 2011 disasters on food industries in different prefectures of Japan



Source: assessment by panel of experts, 2014

The greatest majority of the experts predict no specific long-term impact of the earthquake on food consumption in Aomori, Iwate, Miyagi, Ibaraki and Chiba prefectures, and other parts of Japan (Figure 6). Nevertheless, a good portion of the panel foresees some negative long-term consequences - insignificant to moderate in Tohoku prefectures (mostly moderate for Miyagi prefecture and insignificant for all others), insignificant or significant in the rest of the country. For Fukushima prefectures the greatest part of the experts expect some (insignificant or moderate) negative impact from the earthquake on food consumption. At the same time, the number of experts appreciating no long-term implications in that prefecture is also quite considerable.

Figure 6. Long-term impacts of March 2011 disasters on food consumption in different prefectures of Japan



Source: assessment by panel of experts, 2014

2. Specific impacts of tsunami

2.1. Short-term implications

According to the experts the short and long-term impacts of the 2011 tsunami on agriculture, food industries and food consumption in different regions of the country have been also unlike.

The greatest majority of the experts assess the short-term adverse impact of the tsunami on agriculture as significant in Miyagi and Fukushima prefectures, as moderate in Iwate prefecture, as insignificant in Aomori and Chiba prefectures, and moderate or insignificant in Ibaraki prefecture (Figure 1). As far as the impact on agriculture in the rest of the country is concerned, the experts are divided as half of them assess it as neutral while another half as negative (mostly insignificant).

The specific negative short-term impact of the tsunami on food industries in Miyagi, Fukushima and Iwate prefectures is evaluated as significant by the greatest portion of the

expert panel (Figure 2). In Aomori prefecture that effects is mostly ranged to be moderate while in Chiba prefecture insignificant. For Ibaraki prefecture opinions of the majority are split between significant negative and insignificant. Similarly, the greatest part of the experts evaluates as negative the impact of tsunami on food industry in the rest of the country but there is no agreement on the extent – one part evaluate it as insignificant while another part as moderate or significant. What is more, some experts evaluate the short-term implications for food industries in the rest of Japan as none or even positive.

Most experts estimate there is a negative short-term impact of the tsunami on food consumption in all affected prefectures (Figure 3). The later is mostly described as significant in Miyagi prefecture, significant or moderate in Fukushima prefecture, insignificant in Ibaraki prefecture, insignificant or moderate in Aomori and Chiba prefectures, insignificant or significant in Iwate prefecture. The majority of experts indicate either there is not adverse impact on food consumption in the rest of Japan or it is principally insignificant.

2.2. Long-term implications

According to the biggest part of the experts there will be a significant long-term impact of the tsunami on agriculture in Miyagi and Fukushima prefectures (Figure 4). Most of them assess that effect to be insignificant for Iwate and Ibaraki agriculture. Nevertheless, a good portion of the panel evaluates much more severelly the adverse long-term implications of that disaster on agriculture of the later two prefectures - moderate in Ibaraki prefecture and predominately moderate in Iwate prefecture. The majority of experts do not perceive any long-term impact for Aomori and Chiba prefectures, and the rest of the country. Nevertheless, a good segment of them still believe there will be some negative (mostly insignificant) long-term impact on Aomori and Chiba agriculture.

The greatest proportion of the experts evaluates that there will be a significant negative long-term impact of the tsunami on food industries in Fukushima and Miyagi prefectures, significant or moderate in Iwate prefecture, and a moderate one in Ibaraki prefecture (Figure 5). Most experts expect the negative long-term effect to be insignificant in Aomori prefecture, and none in Chiba prefecture and the rest of the country. Nevertheless, a good part of them foresee some adverse impact (mostly insignificant) in Chiba prefecture and (insignificant) in the rest of Japan.

The majority of the experts predict there will be no specific long-term impact of the tsunami on food consumption in Ibaraki and Chiba prefectures, and other parts of the country (Figure 6). For other four affected prefectures most experts expect some negative longer-term consequences for food consumption, which is mainly evaluated as moderate (for Miyagi and Iwate prefectures) or insignificant (for Aomori and Fukushima prefectures).

3. Specific impacts of nuclear disaster

3.1. Short-term implications

According to the experts the Fukushima nuclear accident's impacts on agriculture, food industries and food consumption in different regions of the country are quite dissimilar.

The experts are unanimous that the specific short-term impact of the nuclear accident on Fukushima agriculture is significant negative (Figure 1). Most of them also assess the short-term impacts of the disaster on Aomori agriculture as insignificant negative. The adverse impact in other badly affected prefectures (Iwate, Miyagi, Ibaraki, and Chiba) and the rest of the country is evaluated chiefly as moderate. Moreover, a good portion of the panel ranks as significant the short-term impact of the accident on Miyagi and Ibaraki agriculture. Some experts also believe there are no negative implications for the agriculture of Aomori, and Chiba prefectures.

The greatest number of experts estimates that the specific short-term impact of the nuclear accident on food industries in the most affected prefectures and the rest of Japan is negative (Figure 2). Most of them range it as significant for Fukushima, Miyagi and Iwate prefectures, and moderate for Chiba and Aomori prefectures and other parts of Japan. The experts are divided for the scale of the negative effect on Ibaraki food industries between significant and moderate. Moreover, some experts believe there is a positive short-term impact from that accident on food industries in other parts of the country.

Almost all experts estimate there is a significant negative short-term impact of the nuclear accident on food consumption in Fukushima prefecture (Figure 3). The majority of them also believe that short-term negative effects on food consumption in Miyagi, Ibaraki, Iwate and Chiba prefectures, and the rest of Japan are significant or moderate. A half of the panel evaluates as insignificant the negative impact on food consumption in Aomori prefecture but another half thinks it is much more adverse (moderate or significant).

The 2014 expertise principally reconfirmed the 2013 expert assessments on impacts of the Fukushima nuclear disaster on agriculture, food industries and food consumption in Fukushima prefecture, neighboring prefectures, and other parts of Japan)Bachev and Ito, 2013).

Most experts agree that the overall agricultural impact from the nuclear disaster in Fukushima prefecture varies considerably according to the specific location of farms since living and working environment, contamination of farmlands and assets, restrictions on entry, production, shipping of produces, etc. have been quite different in the evacuation areas and rest of the prefecture. The common view is that "in the areas of restriction to entry, stay and residence, the recovery of agriculture remains difficult while the other areas are affected by bad reputation".

The major reason for the negative consequences of the nuclear accident on food industries in Fukushima region is specified as "decreasing sales caused by the contamination and harmful rumors". The experts also believe that "in a longer term the recovery of regional food industries will be faster than in the sector agriculture".

The most badly affected by the nuclear disaster areas of agriculture in Fukushima region are described as: harmful rumors, shipping restriction, contaminated farmlands, decreased sales, unable and restricted farming, farming, lowered price of products, declined willingness to continue farming, works to prevent absorbance of radioactive matters, radiation inspections, polluted agricultural mountain products, compensation procedures, destroyed livestock in evacuation area, abolished products, destructed high brand local products, organic agriculture, agricultural management (decreased income), decreased values of farm assets, increased abandoned farmlands, moving farmers to other prefectures, declined consumption of local products by local population, secured market, external exposure to radiation, vegetables, rice, milk, beef, mushrooms, and fruits (Table 1).

Table 1. Most badly affected areas from Fukushima nuclear disaster

In	Agriculture	Food industries	Food consumption
Fukushima region	Harmful rumors (******) Restriction of shipping (*****) Contaminated farmlands (****) Decreased sales (*****) Unable farming due to evacuation (****) Restricted farming (***) Lowered price of products (***) Declined willingness to continue farming (**) Works to prevent absorbance of radioactive matters (**) Radiation inspections (**) Polluted agricultural products (**) and mountain vegetables Procedures for compensation Destroyed livestock in evacuation area Abolished products Destructed high brand local products Organic agriculture Agricultural management (decreased income) Decreased economical values of farm assets Increased abandoned farmlands Some farmers moved to other prefectures Declined consumption of local products by local people Secured market External exposure to radiation Vegetables Rice Milk Beef	Harmful rumors (******) Decreased use of local ingredients (****) Changed places for buying ingredients (***) Increased costs (***) Decreased sales (**) Closed factories because of evacuation (**) Unrecovered consumer trust Safety of local raw materials Excluded from tenders local factories Decreased naming “Made in Fukushima” Management Seafood produces	Avoiding Fukushima products (******) Worries of radioactive contamination (*****) Stopped use of local products for school lunch Increased costs for nonlocal supply Increased costs for buying water, etc. Declined population Whole Fukushima area

	Mushrooms Fruits		
Neighboring regions	Harmful rumors (****) Restriction of shipping (***) Decreased sales (***) Needs of inspection Anxiety about polluted farmland Gradual radioactive pollution Procedure for compensation It depends on density of radioactive substance Vegetables Rice Milk Beef	Harmful rumors (**) Decreased sales (**) Changes in buying ingredients (**) Needs of inspection Inspection fees Worries of consumers Decline in exportation More damages from earthquakes and tsunami It depends on density of radioactive substance. Seafood produce	Anxiety due to radioactive contamination (***) Avoiding East Japan products (**) Decreased consumption of local products Avoiding Fukushima products Harmful rumors Increased costs for buying water, etc.
Other parts of Japan	Worries of radioactive contamination in East Japan Polluted agricultural products and mountain vegetables and little promotion made Declined exportation Restriction of shipping abroad Decreased sales Detected radioactivity in wild plants Beef	Restriction of shipping abroad Changes in buying ingredients	Avoiding East Japan products Avoiding Fukushima products Increased costs for buying water, etc. Increased anxiety

Source: assessment by panel of experts, 2013 * frequency of listing

Some experts are particularly concerned with the "decreased current and future number of farmers" as a result of diminished willingness to farm and moving farmers to other prefectures as well as with the "decreased consumption of local products by local people".

The most badly affected by the nuclear disaster areas of agriculture in the neighboring regions are defined as: harmful rumors, restriction of shipping, decreased sales, needs of inspection, anxiety about polluted farmland, gradual radioactive pollution, procedure for compensation, density of radioactive substance, vegetables, rice, milk, and beef.

As far as agriculture in other parts of the country is concerned, the most badly affected areas from the nuclear disaster are specified as: worries of radioactive contamination in East Japan, polluted agricultural products and mountain vegetables, little promotion made, declined exportation, restriction of shipping abroad, decreased sales, detected radioactivity in wild plants, and beef.

The most badly affected by the nuclear disaster areas of food industries in Fukushima region are identified as: harmful rumors, decreased use of local ingredients, changed places for buying ingredients, increased costs, decreased sales, closed factories because of evacuation, unrecovered consumer trust, safety of local raw materials, excluding from tenders of local factories, decreased naming "Made in Fukushima", management, and seafood produce.

The most badly affected areas of food industries in the neighboring regions are listed as: harmful rumors, decreased sales, changes in buying ingredients, needs of inspection,

inspection fees, worries of consumers, decline in exportation, density of radioactive substance, seafood produces. It is also mentioned that the food industry in these regions has been "more damaged from the earthquakes and tsunami than from the nuclear accident".

As far as food industries in other parts of the country are concerned, the most badly affected areas from the nuclear disaster are specified as: restriction of shipping abroad, and changes in buying ingredients.

The most badly affected areas of food consumption in Fukushima region are determined as: avoiding Fukushima products, worries of radioactive contamination, stopped usage of local products for school lunch, increased costs for nonlocal supply, increased costs for buying water etc., declined population, and the whole Fukushima area.

The most badly affected areas of food consumption in neighboring regions are identified as: anxiety due to radioactive contamination, avoiding East Japan products, decreased consumption of local products, avoiding Fukushima products, harmful rumors, and increased costs for buying water etc.

The most affected areas of food consumption in other parts of Japan are listed as: avoiding East Japan products, avoiding Fukushima products, increased costs for buying water etc., and increased anxiety.

3.2. Long-term implications

According to all experts there will be a significant long-term negative impact of the nuclear accident on agriculture in Fukushima prefecture (Figure 4). Most experts also predict that in a longer term the Fukushima nuclear disaster will cause a moderate negative impact on Iwate, Miyagi and Ibaraki agriculture, insignificant one on agriculture in Chiba prefecture and the rest of Japan. For long-term consequences on Aomori agriculture the majority of experts are divided between none and insignificant adverse effects. Nevertheless, a good portion of the experts foresees significant negative long-term implications on Miyagi agriculture, and more severe (moderate to significant) on Aomori and Chiba agriculture.

The greatest segment of the experts evaluate that there will be a significant negative long-term impact of the nuclear accident on food industries in Fukushima prefecture (Figure 5). For other prefectures the largest part of the experts expects some negative consequences for food industries mostly assessed as significant for Miyagi prefecture, moderate for Ibaraki prefecture, and insignificant for Aomori, Iwate and Chiba prefectures and the rest of Japan. At the same time, a good proportion of the panel does not expect any negative impacts on Aomori, Chiba and the rest of Japan food industries in a longer term.

All experts expect there will be a negative long-term impact of the Fukushima nuclear disaster on food consumption in Fukushima prefecture, mostly ranged as significant (Figure 6). The majority of experts also suggest there will be some adverse long-term impactions from the nuclear disaster on food consumption in other badly affected prefectures as well as the rest of Japan. The later are mostly estimated to be moderate in Aomori, Iwate, Miyagi, Ibaraki, and Chiba prefectures, and insignificant for the rest of the country. Nevertheless, a third of the experts do not expect any long-term negative implications from that accident for food consumption in Chiba prefecture and the rest of the country. The same is true according to a

fifth of the experts as far as the food consumption in Aomori, Iwate, Miyagi and Ibaraki prefectures is concerned.

All these foresights have basically reconfirmed the 2013 experts assessments on long-term impacts of the Fukushima nuclear disaster on agriculture, food industries, and food consumption in Fukushima prefecture, neighboring prefectures and the rest of the country (Bachev and Ito, 2013).

4. Combined impacts of 2011 disasters

4.1. Short-term implications

Finally the experts have assessed the combined impacts of the triple 2011 disaster on agriculture, food industries and food consumption in different parts of the country.

The combined short-term impact of the 2011 disasters on agriculture in all regions is negative. According to all experts the disasters' overall short-term impact on Fukushima agriculture is significant negative (Figure 1). All experts also evaluate as significant or moderate the short-term impacts on Miyagi and Iwate agriculture (mostly scaled as significant). The adverse short-term implications on Ibaraki and Chiba agriculture are predominately ranked as moderate. The negative short-term impact on agriculture of Aomori prefecture and other parts of Japan is commonly evaluated as insignificant.

According to the great majority of all experts the combined short-term impact of the 2011 disasters on food industries in all regions is negative (Figure 2). There is a full consensus among experts on the severity of the adverse effect on Fukushima food industries, which is inclusively jugged as significant. Most experts also assess as significant the negative impact on food industries in Miyagi, Iwate and Ibaraki prefectures. The short-term impact on food industries in Chiba prefecture is predominately evaluated as moderate, and in Aomori prefecture and the rest of the country as insignificant. Nevertheless, a good number of the experts also believe in a stronger (moderate and significant) negative impact in Aomori prefecture and the rest of the country. Furthermore, some experts think the 2011 disasters had a combined positive short-term impact on food industries in other parts of the country.

The experts also estimate that the combined short-term impact of the 2011 disasters on food consumption in all regions of the country has been negative (Figure 3). The food consumption in Fukushima prefecture has been the most severely affected where the general assessment is significant negative. The biggest part of the experts estimates that the adverse short-term impact has been considerable in all other badly affected prefectures as well as the rest of the country. The later is mostly ranked as significant throughout all regions with exception of Aomori prefecture where the common estimate is moderate.

According to the experts the most badly affected by the 2011 disasters areas of agriculture in Aomori prefecture are: paddy fields, vegetable farming, livestock, and apple production (Table 2). The most severely impacted areas of food industries in the prefecture are: equipment, inputs supply, marine products, rice milling, milk processing, and fish industry. The most badly affected areas of food consumption in this prefecture are: vegetables, apple and other fruits, rice, milk, and fish.

Table 2. Most badly affected areas from March 2011 disasters

Regions	Agriculture	Food industries	Food consumption
Aomori prefecture	Paddy fields (**) Vegetable farming Livestock Apple production	Equipment Inputs supply Marine products Rice milling Milk processing Fish industry	Vegetables Apple and other fruits Rice Milk Fish
Iwate prefecture	Paddy fields (***) Paddy fields near seashore Livestock (****) Buildings Mushrooms Vegetable farming Irrigation Fisheries	Equipment Inputs supply Seafood processing Marine products Processing factories Rice milling Milk processing Dairy industry	Eligible wild plants Vegetables Fruits Rice Milk Dairy products
Miyagi prefecture	Paddy fields (*******) Buildings Hamlet infrastructure Mushrooms Community Agricultural machinery Livestock Vegetable farming Irrigation Labor availability Restoration of farmland in some areas Fisheries	Equipment Inputs supply Seafood processing Marine products Processing factories Rice milling Milk processing Labor availability Fish industry Shellfish products	Eligible wild plants Vegetables Fruits Rice Milk Fish
Fukushima prefecture	Paddy fields (******) Fields Livestock (***) Irrigation (**) All agricultural products Hamlet infrastructure Brand reputation Labor Soil and water Community Vegetable farming Peach production Fisheries Reputation	Equipment Aizu brand reputation Inputs supply Brand reputation Reputation Many brands Price Rice milling Milk processing Fish industry Shellfish products Coastal fish products	Eligible wild plants Food self-sufficiency Vegetables Fruits Rice Milk Fish Reputation
Ibaraki prefecture	Paddy fields (**) Buildings Livestock Vegetable farming Irrigation Fisheries	Rice milling Milk processing Fish industry Shellfish products	Eligible wild plants Vegetables Fruits Rice Milk Leaf vegetables
Chiba prefecture	Paddy fields (**) Buildings Vegetable farming	Rice milling Milk processing Fish industry	Vegetables Fruits Rice

	Livestock	Shellfish products	Milk Leaf vegetables
Other parts of Japan	Brand reputation Vegetable farming Paddy fields	Fish industry	Vegetables Apple and other fruits Rice Milk Fish

Source: assessment by panel of experts, 2014 * frequency of listing

The worst affected by the 2011 disasters areas of agriculture in Iwate prefecture are identified as: paddy fields, paddy fields near seashore, livestock, buildings, mushrooms, vegetable farming, irrigation, and fisheries. The most badly impacted areas of the prefectural food industries are: equipment, inputs supply, seafood processing, marine products, processing factories, rice milling, milk processing, and dairy industry. The most affected areas of food consumption in this prefecture are: eligible wild plants, vegetables, fruits, rice, milk, and dairy products.

The worst affected by the 2011 disasters areas of agriculture in Miyagi prefecture are specified as: paddy fields, buildings, hamlet infrastructure, mushrooms, community, agricultural machinery livestock, vegetable farming, irrigation, labor availability, restoration of farmland in some areas, and fisheries. As the most badly impacted areas of food industries in the prefectures are listed: equipment, inputs supply, seafood processing, marine products, processing factories, rice milling, milk processing, labor availability, fish industry, and shellfish products. The most severely affected areas of food consumption in this prefecture are: eligible wild plants, vegetables, fruits, rice, milk, and fish.

In Fukushima prefecture the most badly affected by the triple disaster areas of agriculture are identified as: paddy fields, fields, livestock, irrigation, hamlet infrastructure, brand reputation, labor, soil and water, community, vegetable farming, peach production, fisheries, and reputation. The worst affected areas of prefectural food industries are: equipment, Aizu and other brands reputation, inputs supply, brand reputation, reputation, price, rice milling, milk processing, fish industry, shellfish products, and coastal fish products. The most badly impacted areas of food consumption in this prefecture are: eligible wild plants, food self-sufficiency, vegetables, fruits, rice, milk, fish, and reputation.

The most badly affected by the 2011 disasters areas of agriculture in Ibaraki prefecture are specified as: paddy fields, buildings, livestock, vegetable farming, irrigation, and fisheries. The worst impacted areas of food industries in the prefecture are: rice milling, milk processing, fish industry, and shellfish products. The most severely affected areas of food consumption in this prefecture are: eligible wild plants, vegetables, fruits, rice, milk, and leaf vegetables.

In Chiba prefecture the most badly affected by the triple disaster areas of agriculture are identified as: paddy fields, buildings, vegetable farming, and livestock. The worst impacted areas of food industries in the prefecture are: rice milling, milk processing, fish industry, and shellfish products. Adverse effect on food consumption in this prefecture is in the area of: vegetables, fruits, rice, milk, and leaf vegetables.

In other parts of the country the most badly affected by the 2011 disasters areas are brand reputation, vegetable farming, and paddy fields in agriculture; fish industry; and vegetables, apple and other fruits, rice, milk, and fish consumption.

In addition, many experts have underlined that there are considerable differences in the impacts in major regions (like Tohoku, Kanto, rest of Japan) as well as among individual areas of each prefecture. Therefore, in depth studies for each area are necessary in order to better understand diverse impacts and factors of the disasters.

Furthermore, some experts have pointed out that the 2011 disasters added some complication to already existing problems like aging communities in rural areas. The lost community identity by many people, avoidance of Tohoku products, and labor scarcity in certain industries (e.g. marine), all they have been also highlighted by some experts.

One expert has commented that the March 2011 disasters hurt a lot the agri-food chain but some subsectors (like vegetable and fruit marketing) quickly restarted in Miyagi prefecture thanks to the small commercial shops (Yaoya). The later rapidly secured vegetables and fruits supply from local producers (on March 12, 2011) and proved that small size marketing business is much more resilient during a big disaster comparing to "highly efficient" large operators (supermarkets).

4.2. Long-term implications

According to all experts there will be a significant negative long-term impact of the 2011 disasters on agriculture in Fukushima prefecture (Figure 4). The majority of the experts also expect a significant impact on Miyagi agriculture and moderate one on Iwate agriculture. For Aomori, Ibaraki and Chiba agriculture the majority foresee insignificant long-term adverse implications. However, a good share among experts also believes there will be stronger long-term negative consequences for agriculture in these three prefectures (particularly Ibaraki and Chiba). At the same time, a good portion of the panel perceives no adverse implication in a longer term for Aomori and Chiba agriculture – almost a third and a quarter of experts accordingly. While the bulk of the experts do not project any long-term implication on agriculture in other parts of Japan, a good portion of them still believe there will be some (mostly insignificant or moderate) negative impacts.

The greatest part of the experts estimate there will be a significant negative long-term impact of the 2011 disasters on food industries in Fukushima and Miyagi prefectures (Figure 5). Most of them also expect significant negative consequences on Iwate food industries, moderate one for Ibaraki prefecture, and insignificant ones in Aomori and Chiba prefectures. Nevertheless, a good portion of the panel believes there will be no long-term implications for Chiba, Ibaraki, and Iwate food industries. Most experts indicate they see no long-term consequences from the 2011 disasters for food industries in other parts of Japan as well. However, many among them believe there will be some type of negative impacts on a longer run.

Two-third of the experts predict that the combined long-term impact of the 2011 disasters on food consumption in Fukushima prefecture will be significantly negative while a quarter among them project it is to be moderate negative (Figure 6). The greatest portion of the experts also believes there will be some negative consequences on food consumption in all other regions of the country - mostly evaluate as moderate and insignificant. Nevertheless,

many experts predict there will be no long-term effects from the disasters in relation to food consumption in all these regions.

5. Long-term impacts on different aspects of agri-food sector development

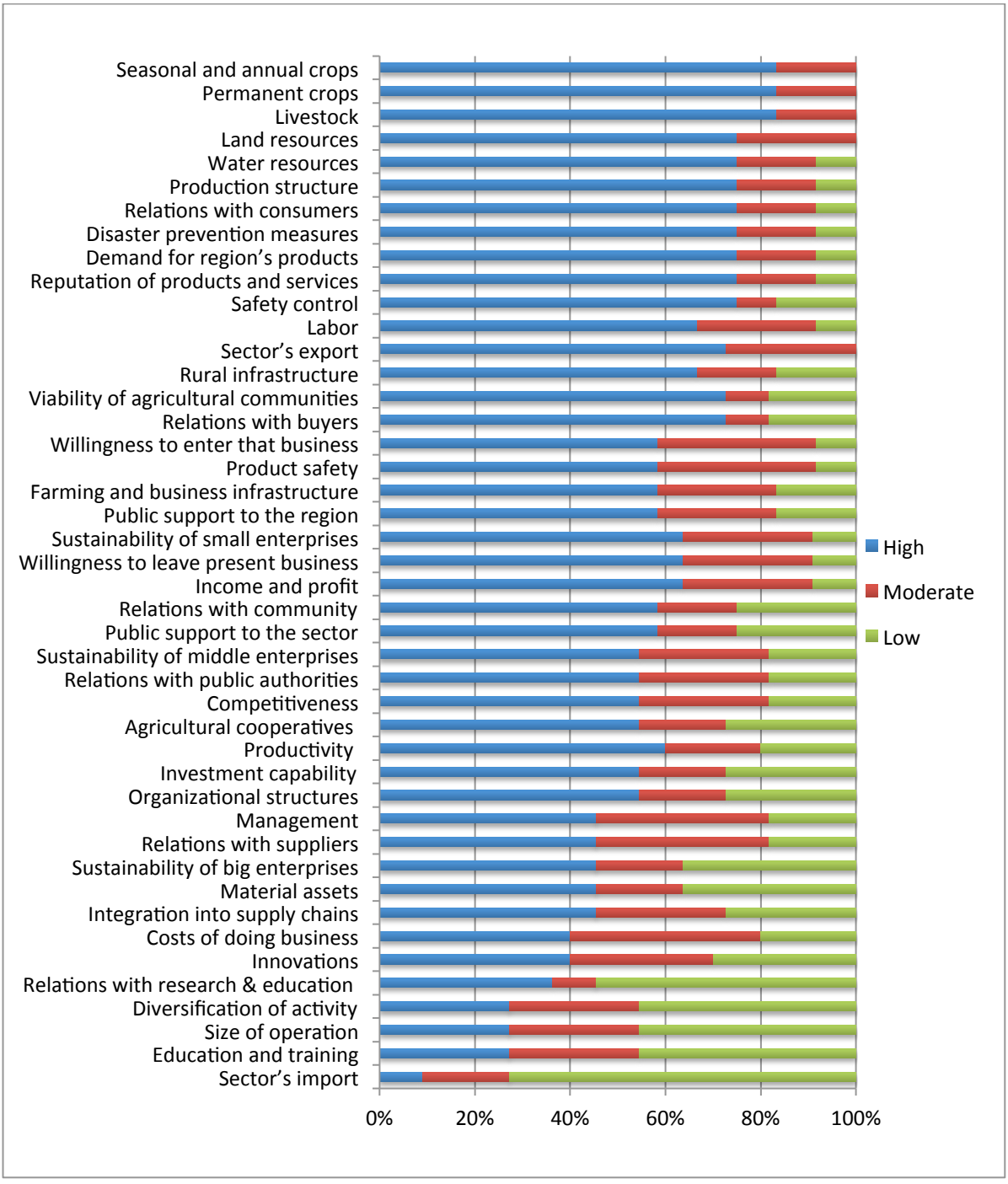
The expert panel has also assessed the long-term effects of the 2011 disasters on different aspects of the agri-food development in most affected regions and the rest of Japan.

According to the experts, in the longer term the mostly affected by the disasters areas of agri-food sector in Fukushima prefecture are likely to be: livestock, permanent crops, seasonal and annual crops, water and land resources, production structure, relations with buyers, disaster prevention measures, demand for region's products, reputation of products and services, safety control, labor, sector's export, viability of agricultural communities, rural infrastructure, relations with buyers, willingness to enter that business, product safety, farming and business infrastructure, public support to the region, sustainability of small enterprises, willingness to leave present business, income and profit, relations with community, and public support to the sector (Figure 7). The greatest majority of the experts evaluate the level of long-term effects in all these areas as high.

The biggest part of the panel also predicts there will be a considerable (moderate or high) long-term impact on sustainability of middle size enterprises, relations with public authorities, competitiveness, agricultural cooperatives, productivity, investment capability, organizational structures, management, and relations with suppliers of prefectural agri-food sector.

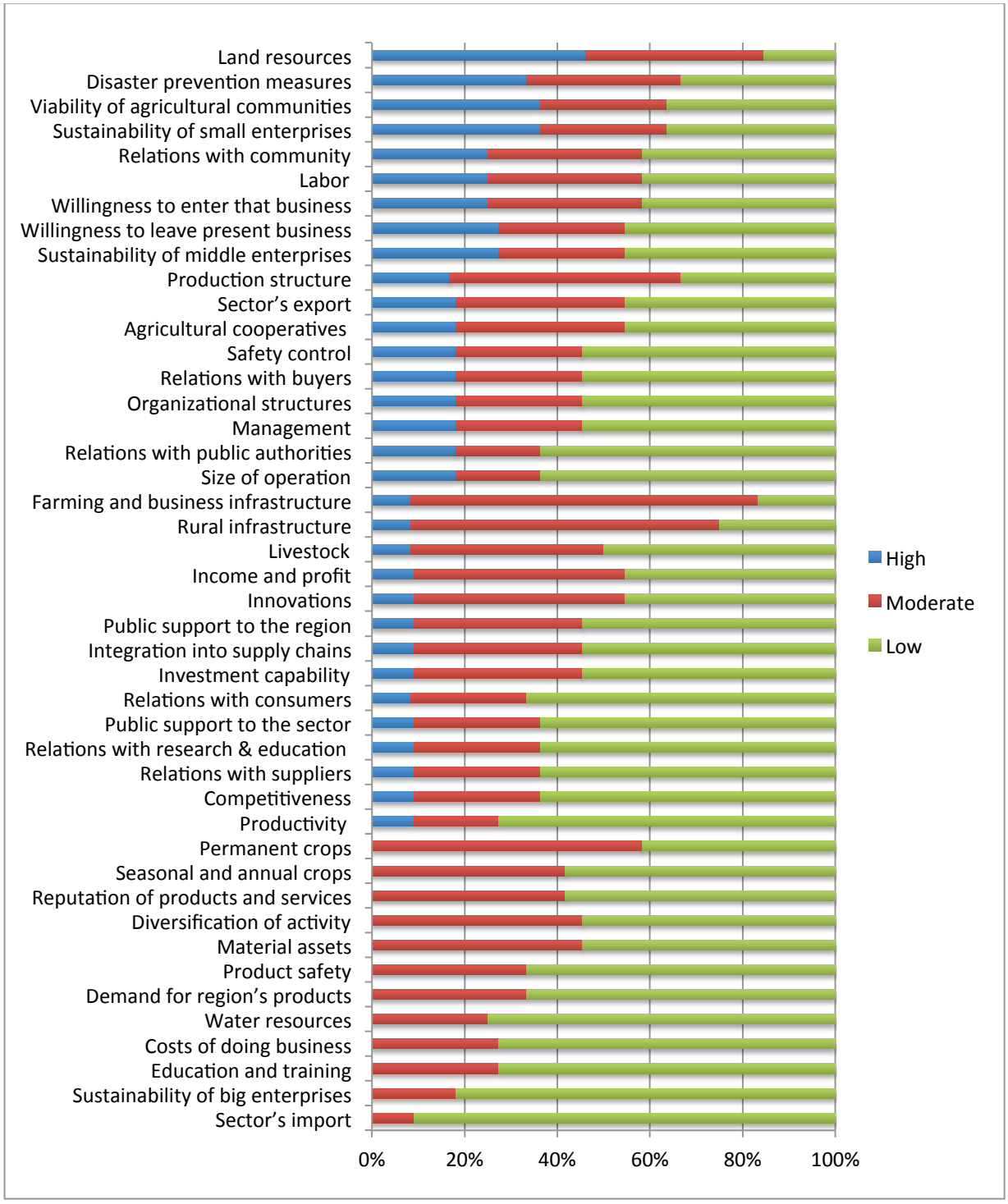
In the long-term the most severely affected by the disasters area of agri-food sector of Miyagi prefecture is specified to be land resources (Figure 8). The greatest majority of the experts also expect a considerable (moderate or high) long-term effect on disaster prevention measures, viability of agricultural communities, sustainability of small enterprises, relations with community, labor, and willingness to enter agri-food business in the prefecture. Besides, a good number of the experts project significant long-term implications on willingness to leave present business, sustainability of middles size enterprises, and production structure of Miyagi agri-food sector. The long-term impacts of the disasters on all other areas of the agri-food development are ranked as less important in this prefecture.

Figure 7. Longer-term effects of March 2011 disasters on different aspects of agri-food sector in Fukushima prefecture



Source: assessment by panel of experts, 2014

Figure 8. Longer-term effects of March 2011 disasters on different aspects of agri-food sector in Miyagi prefecture

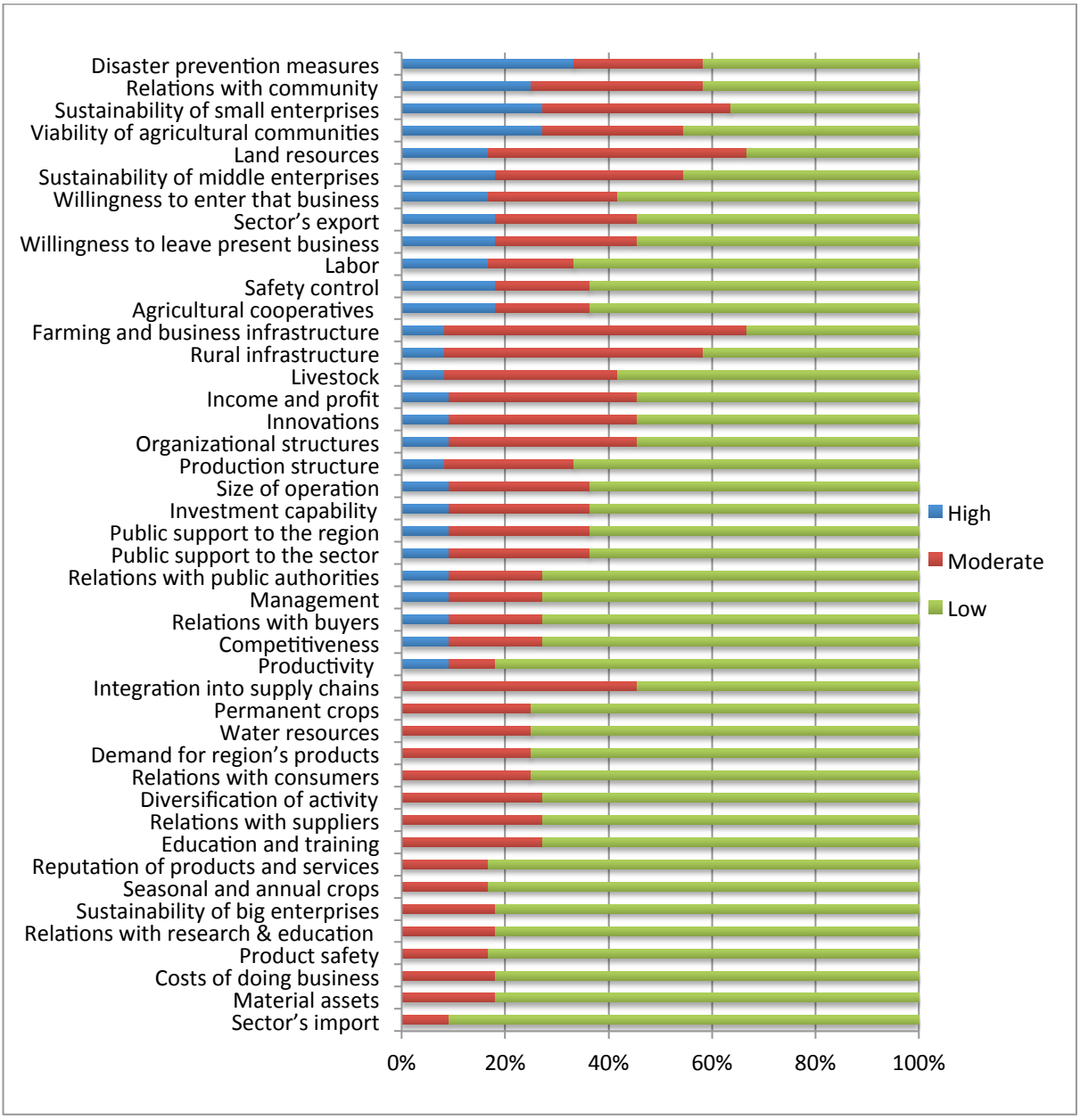


Source: assessment by panel of experts, 2014

In Iwate prefecture the majority of experts expect a more substantial (moderate or high) long-term effect by the 2011 disasters on agri-food sector in following areas: disaster prevention measures, relations with community, sustainability of small enterprises, viability of agricultural communities, and land resources (Figure 9). A good number of them also

project a significant impact on sustainability of middle size enterprises, farming and business infrastructure, and rural infrastructure in the prefecture. On the other hand, the majority of experts foresee no significant implications for all other areas of agri-food sector in this prefecture.

Figure 9. Longer-term effects of March 2011 disasters on different aspects of agri-food sector in Iwate prefecture



Source: assessment by panel of experts, 2014

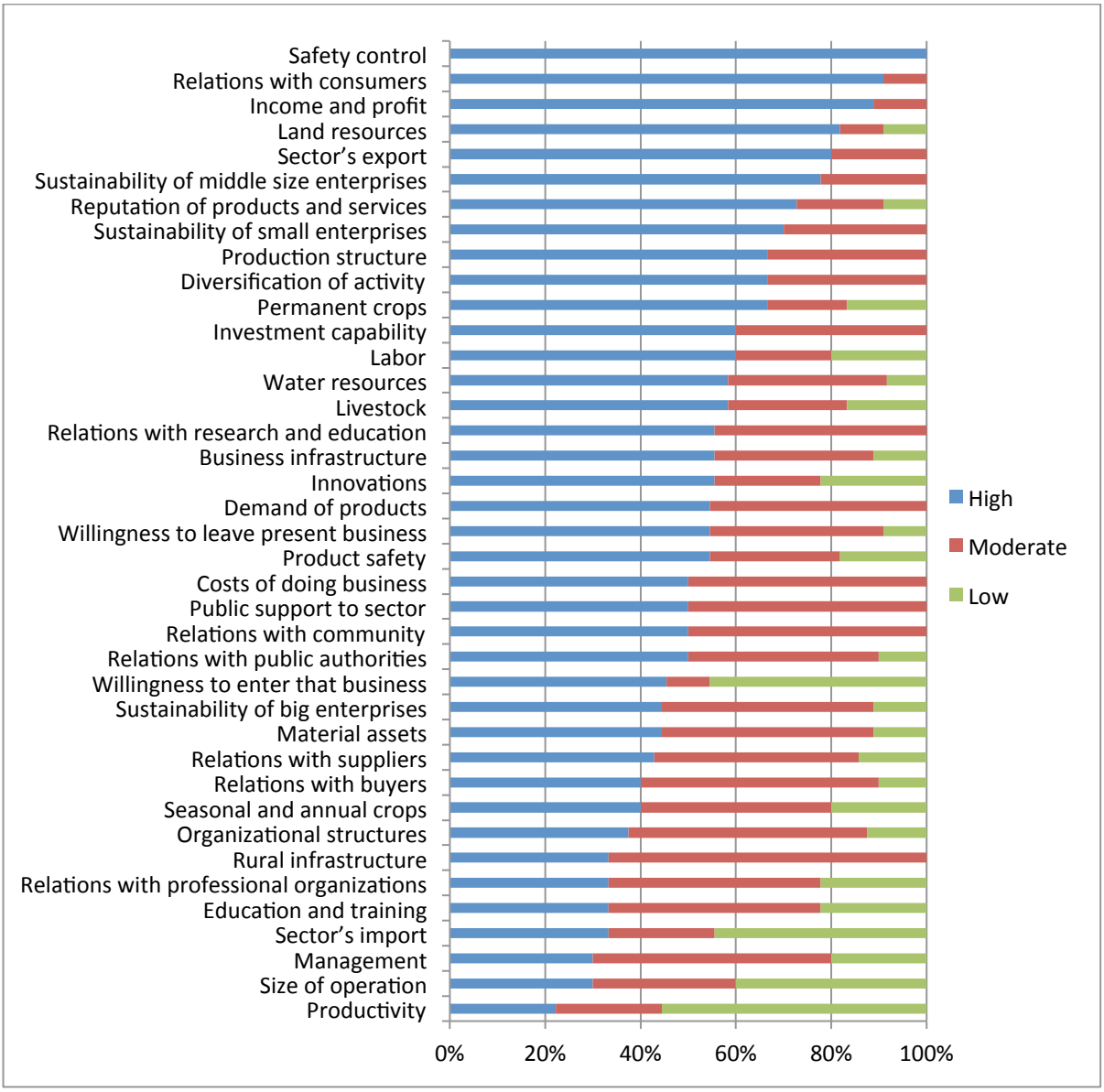
For other parts of the country, a bigger part of the experts (almost 39%) only envisage a high or moderate long-term effect of the 2011 disasters on disaster prevention measures. A good number of the panel (almost 31%) also anticipates more substantial (mainly moderate) impact on sector's export and safety control. In all other areas of the agri-food sector

development the greatest proportion of experts see no long-term implications for the rest of the country.

The expert panel has also assessed the long-term effects of the Fukushima nuclear disaster on different aspects of agriculture and food industries development.

The experts are unanimous that there will be a high long-term effect on food safety in agriculture (Figure 10). They also expect there will be a significant effect on relations with consumers, income and profit, and land resources in the sector. Furthermore, there will be high or moderate effects on sector's export, sustainability of small and middle size enterprises, reputation of products and services, diversification of activity, permanent crops, investment capability, labor, water resources, livestock, relations with research and education institutions, demand of products, willingness to leave present business, product safety, costs of doing business, public support to sector, and relations with community.

Figure 1o. Long-term effects of Fukushima nuclear disaster in agriculture

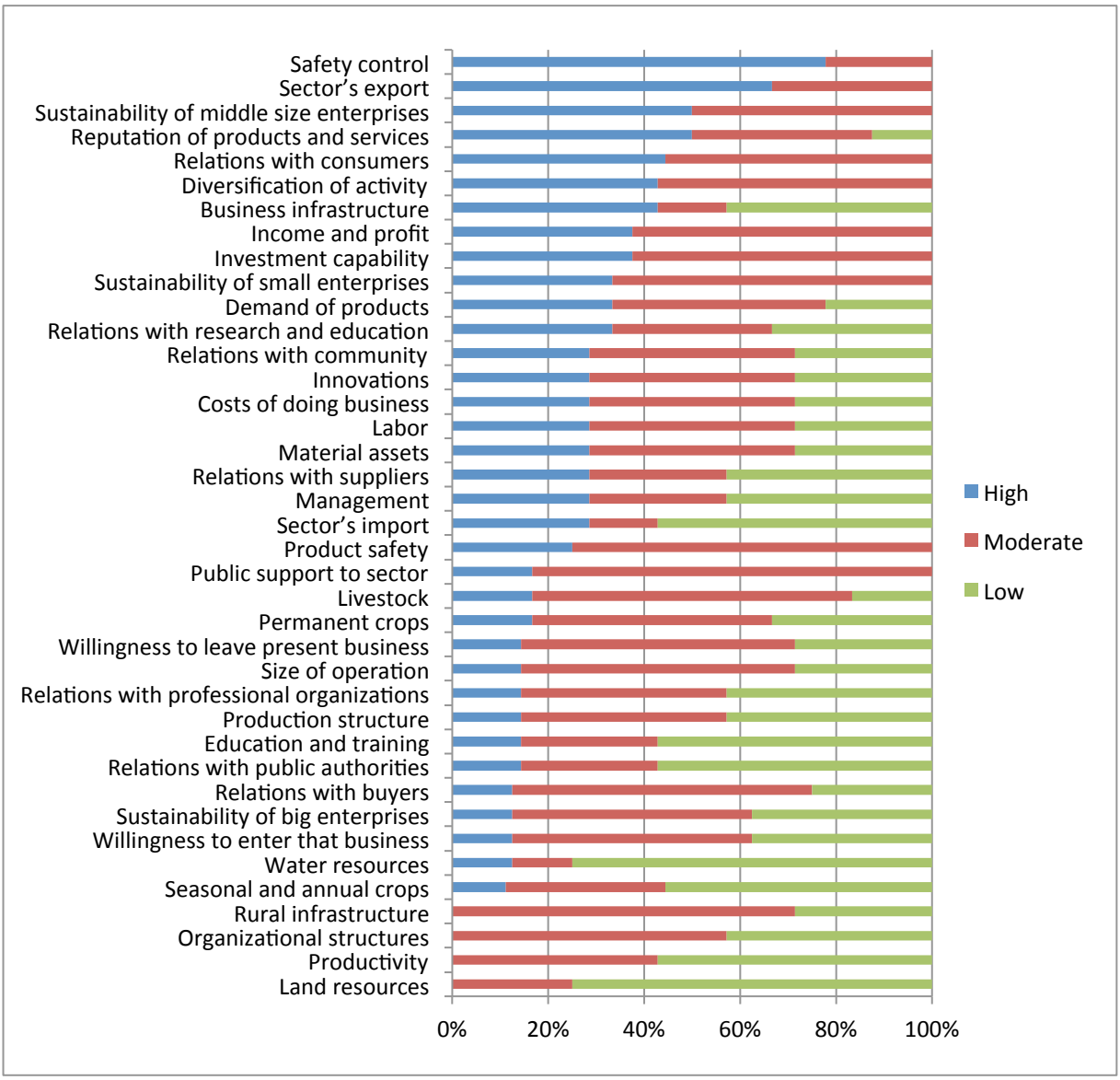


Source: assessment by panel of experts, 2013

On the other hand, the long-term effects on rural infrastructure, relations with buyers, organizational structures, and management in that sector are mostly estimated as moderate. Finally, according to the experts the nuclear disaster will have only a low effect on productivity and willingness to enter that business.

The strongest long-term effect of the nuclear disaster in food industries will be on safety control and sector's export (Figure 11). There will be also high and moderate consequences on sustainability of middle size enterprises, and reputation of products and services in this sector.

Figure 11. Long-term effects of Fukushima nuclear disaster in food industries



Source: assessment by panel of experts, 2013

The long-term effects on sustainability of small enterprises, product safety, public support to sector, willingness to leave present business, size of operation, relations with buyers, relations with consumers, diversification of activity, relations with consumers, income and profit, investment capability, sustainability of big enterprises, willingness to enter that

business, rural infrastructure, and organizational structures, are predominately evaluated as moderate by the experts.

According to the most experts the long-term effects of the nuclear disaster on land and water resources, sector's import, productivity, relations with public authorities, relations with suppliers, management, education and training in the food industries are expected to be rather low.

6. Factors for persistence of negative impacts of 2011 disasters

The expert panel has identified the major factors for the persistence of the negative impacts of the 2011 disasters on agri-food sector in the most affected regions and nationwide.

According to the great majority of the experts the most important factors for the adverse effects' continuation in the agri-food sector of Fukushima prefecture are: the destruction of traditional communities, consumers unwillingness to buy, bad reputation, long time required for cleaning and restoration of lands, slow restoration of infrastructure and services, and high radiation (Figure 12).

More than a half of the experts also point out as critical factors for sustaining the negative impacts in the prefecture: the lack of consensus in local communities, lack of labor, insufficient support from the central government, bad communication, and health risk concerns. Furthermore, a good number of the experts also believe that crucial for maintaining the negative consequences in the prefecture has been: the slow process of returning evacuees back to home places, unresolved permanent radiation waste storage issue, low confidence in the official information, and the government's bans on production and/or sells.

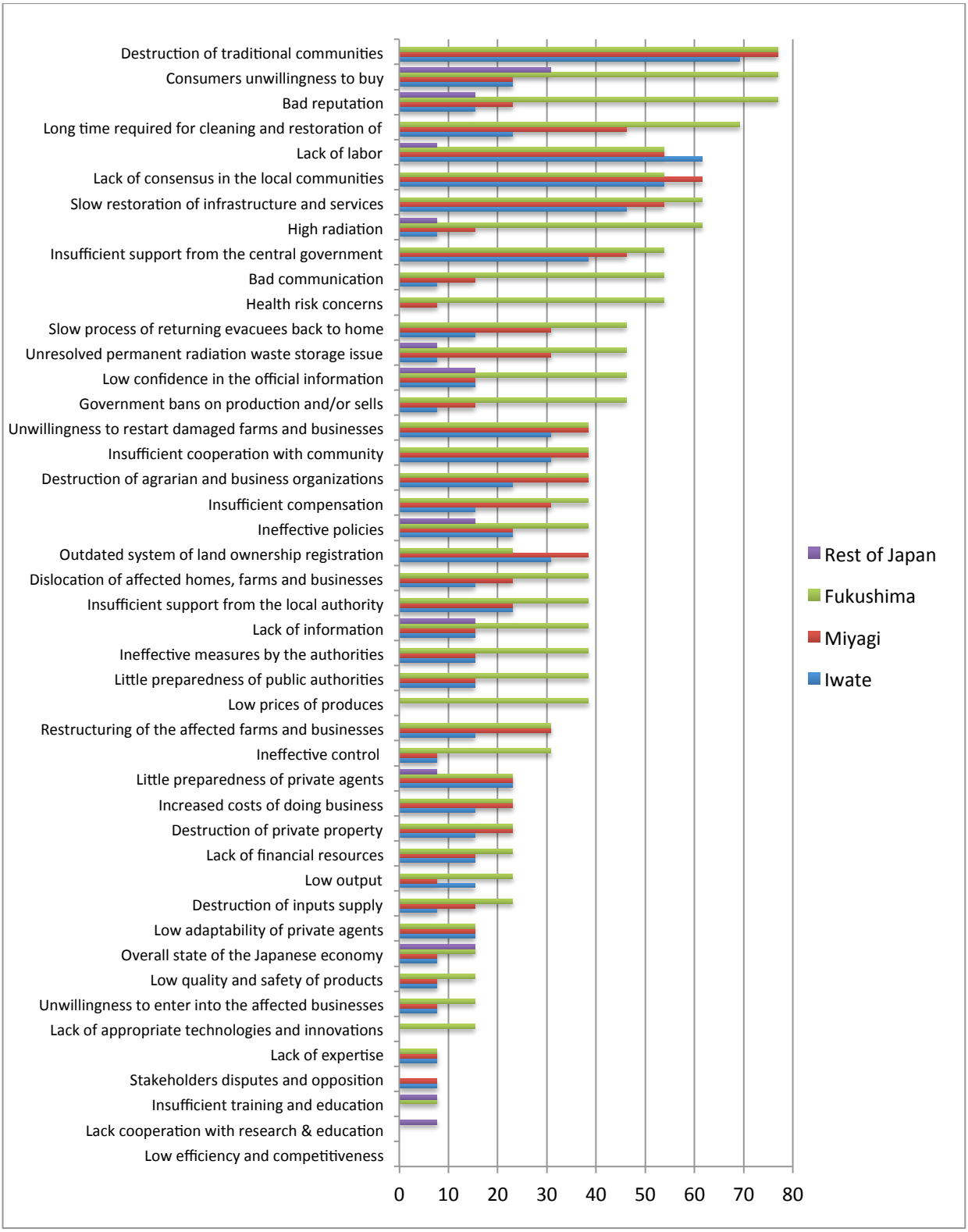
According to the majority of the experts the most important factors for the persistence of negative impacts in agri-food sector of Miyagi prefecture are: the destruction of traditional communities, lack of consensus in the local communities, slow restoration of infrastructure and services, and lack of labor.

A good number of experts also underline as critical factors in this prefecture: the long time required for cleaning and restoration of lands, and insufficient support from the central government.

The majority of the experts are convinced that the most important factors for the persistence of the negative consequences from the 2011 disasters in Iwate agri-food sector are: the destruction of traditional communities, lack of labor, and lack of consensus in the local communities. In addition, numerous experts have pointed out the slow restoration of infrastructure and services as an important factor.

For the other parts of the country the majority has identified no single factor for the persistence of the adverse consequences of the triple disater. Nevertheless, almost 31% of the experts estimate that the consumers' unwillingness to buy has been an important factor, while just above 15% specify as such: the bad reputation, low confidence in the official information, ineffective policies, lack of information, and overall state of the Japanese economy.

Figure 12. Factors[5] for persistence of negative impacts of March 2011 disasters on agri-food sector (percent)



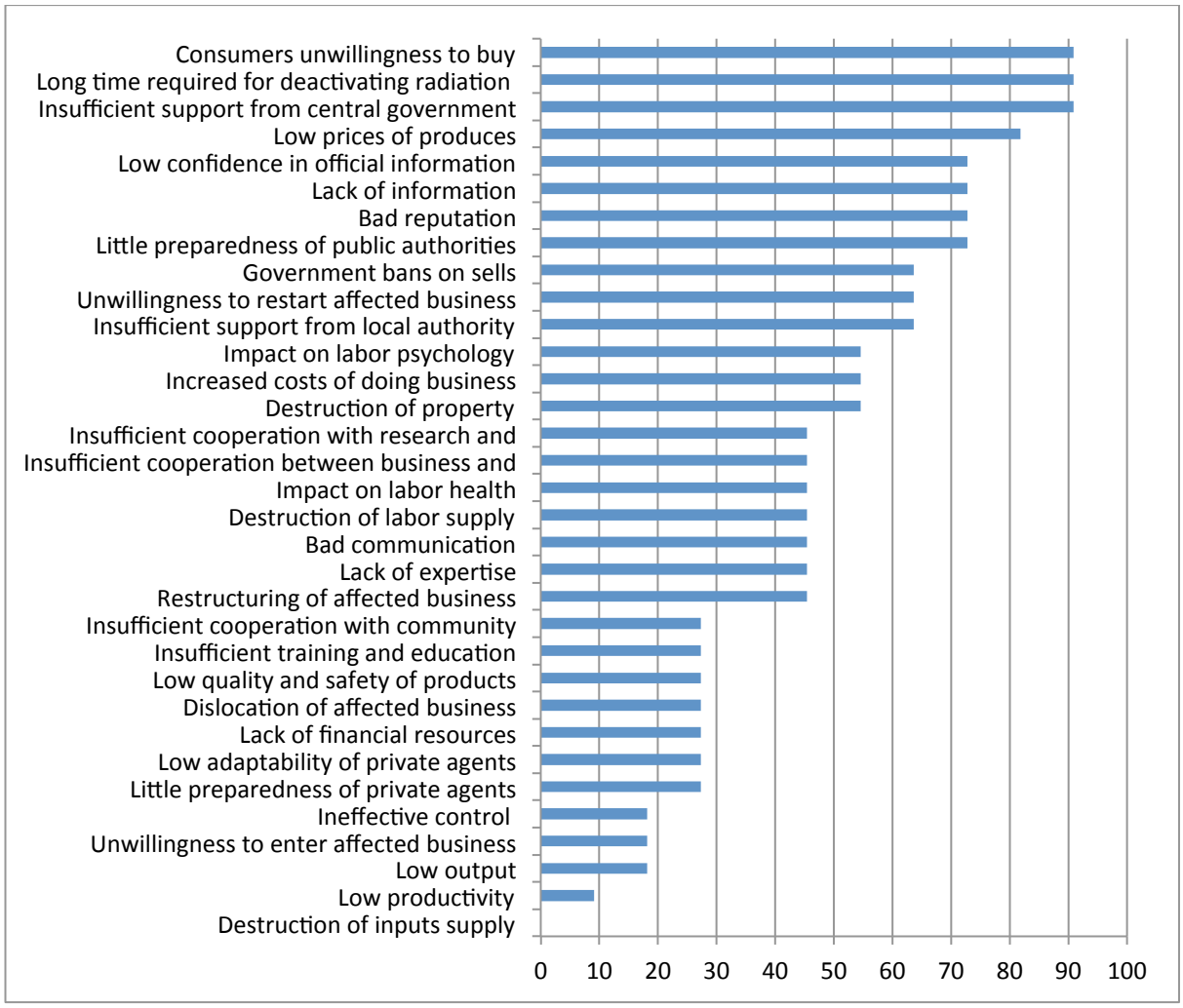
Source: assessment by panel of experts, 2014

[5] One expert has added to the list ”Recent agricultural policy reform” as an important factor for all regions.

The expert panel has also identified the major factors for the persistence of negative impacts of the Fukushima nuclear disaster on agriculture, food industries and food consumption.

The most important factors for the persistence of the nuclear accident's negative impacts on agriculture are: the consumers unwillingness to buy, long time required for deactivating radiation, insufficient support from the central government, and low prices of produce (Figure 13). The low confidence in official information, lack of information, bad reputation, and little preparedness of public authorities are also identified as significant factors for sustaining disaster's negative consequences in this sector.

Figure 13. Factors for persistence of negative impacts of Fukushima nuclear disaster on agriculture (percent)

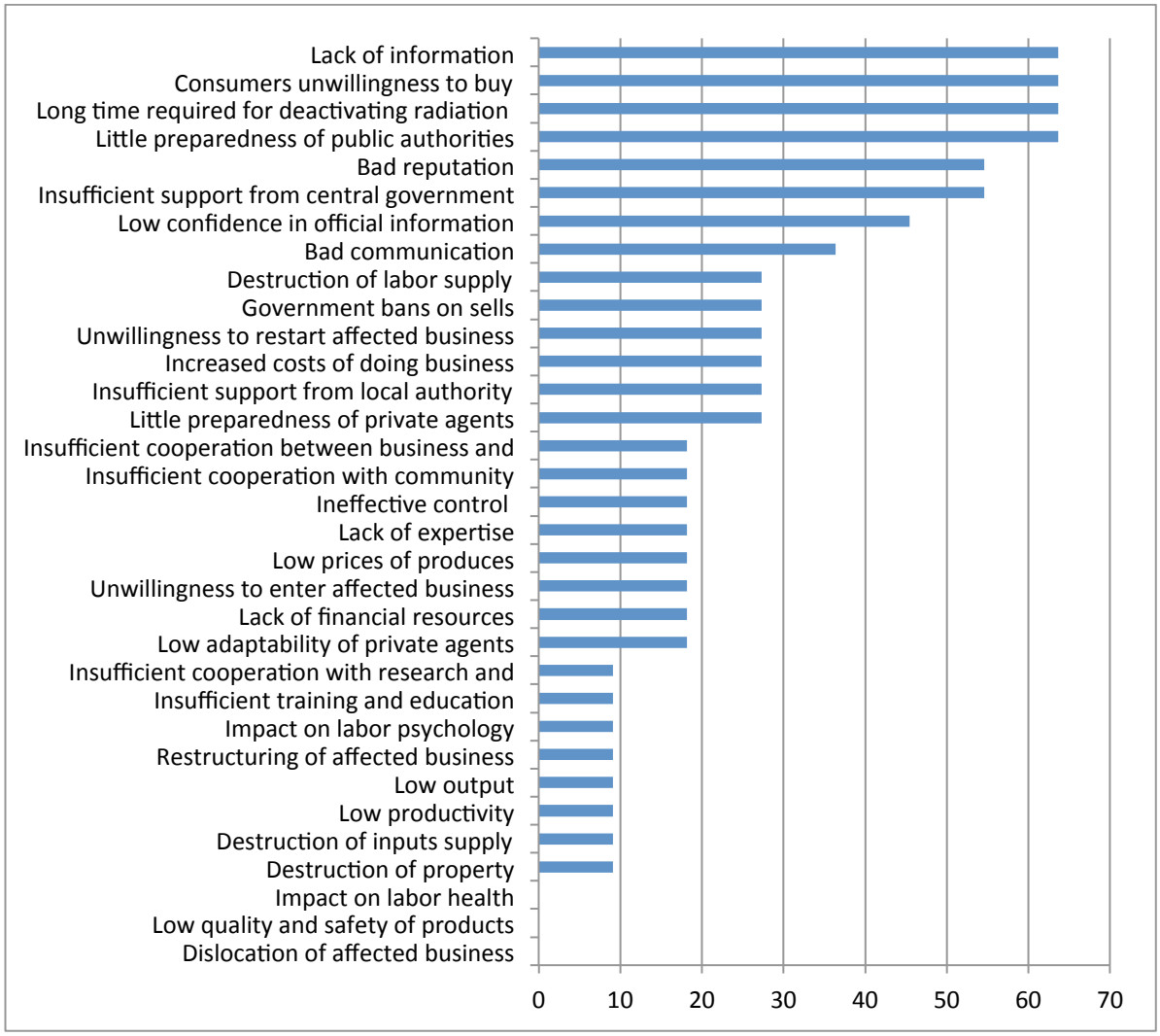


Source: assessment by panel of experts, 2013

The most important factors for the persistence of negative impacts of the nuclear disaster on food industries are: the lack of information, consumers unwillingness to buy, long time required for deactivating radiation, and little preparedness of public authorities (Figure 14). Besides, the bad reputation, insufficient support from the central government, and low

confidence in official information are also ranked as key factors for the persistence of negative effects on food industries.

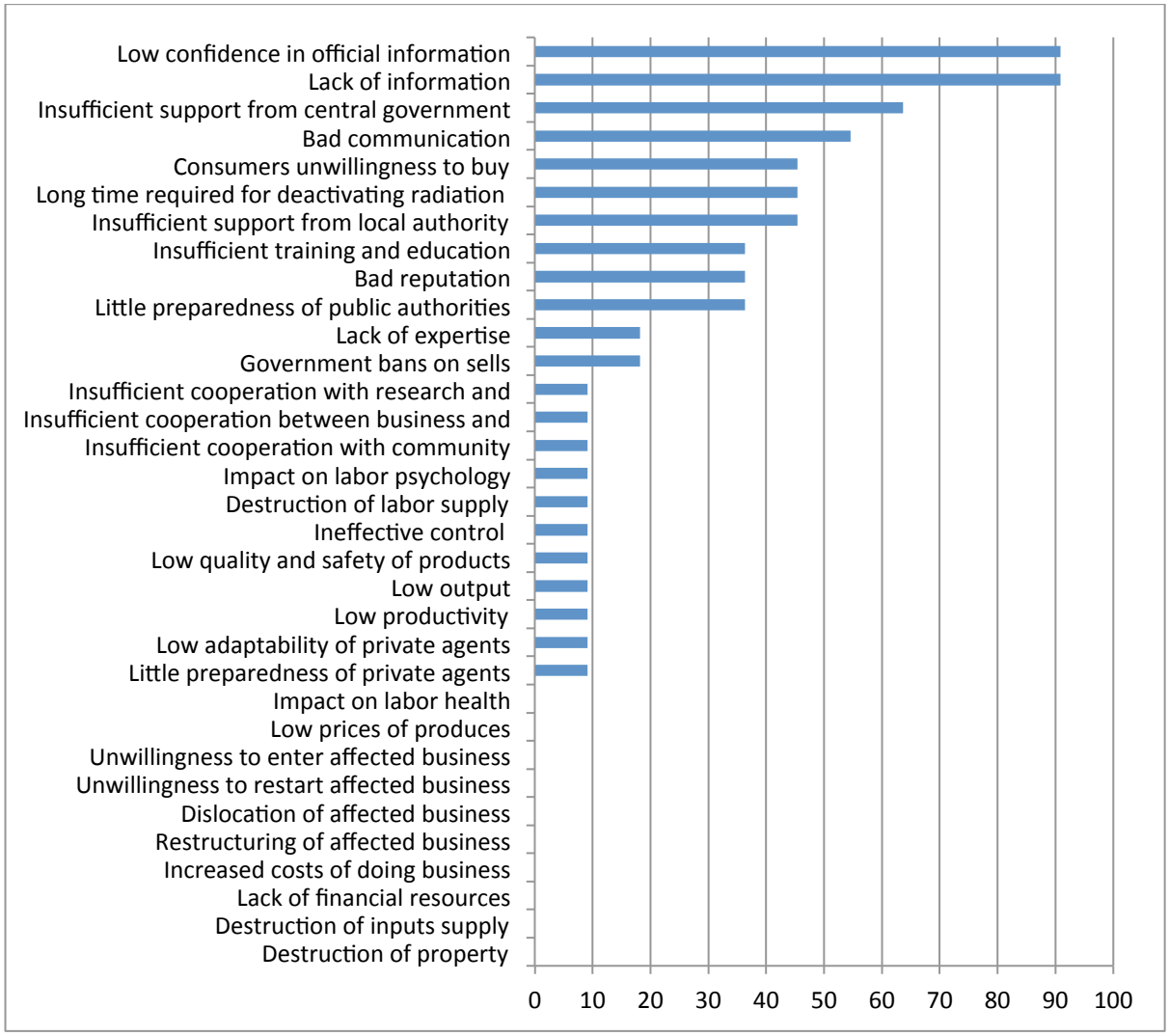
Figure 14. Factors for persistence of negative impacts of Fukushima nuclear disaster on food industries (percent)



Source: assessment by panel of experts, 2013

As far as the most important factors for the persistence of negative impacts of the nuclear disaster on food consumption is concerned, they are identified as: the lack of information, and low confidence in official information (Figure 15). In addition, a good portion of the experts believe that insufficient support from the central government and bad reputation are significant for sustaining negative impacts of that disaster on food consumption.

Figure 15. Factors for persistence of negative impacts of Fukushima nuclear disaster on food consumption (percent)



Source: assessment by panel of experts, 2013

Conclusion

Agriculture, food industry and food consumption have been among the worst hit by the disasters areas. Agri-food sectors of Fukushima, Miyagi and Iwate prefectures have been particularly severely affected in the short and longer term. There are also significant adverse consequences on other (neighboring) regions and entire food chains at a larger (regional, national, international) scale.

There is a great variation of the specific and combined impacts of the earthquake, tsunami, and nuclear disaster on different type of farming and business enterprises (small-big scale, specialized, diversified, integrated), particular agents (producers, processors, distributors, consumers, community and public organizations), individual sub-sectors (rice, vegetables, beef), and specific locations (evacuation zone, seaside).

Moreover, there have been enormous damages and long-term consequences on farming and rural households, important properties (farmland, livestock, orchards), personal ties, established brands, informal organizations and traditional communities. Many of all these negative effects can hardly be adequately expressed in quantitative (e.g. monetary) terms. In addition, the 2011 disasters have considerably aggravated some already existing problems of the agrarian and rural regions such as: aging and shrinking population, lack of labor and young entrepreneurs, low competitiveness and efficiency, income and services disparities, etc.

The specific responses to the 2011 disasters have highlighted the comparative advantages of traditional communities and non-governmental organizations, and certain less "efficient" but more resilient structures (such as small operators, partnerships) and sectors (one season crops, poultry, pig, processing). What is more, the disasters have had positive impacts on the development of certain (more resilient, adaptive) sectors in the most affected regions and some (traditional, prospective) sectors in other parts of the country.

The post disaster recovery and reconstruction have also given opportunities and induced considerable policies and institutional modernization in agrarian and other (e.g. energy, security) sectors, and improve disaster prevention and management, food safety information and inspection, technological and product innovation, jobs creation and investment (including in "new" areas such as research and innovation, ICT, renewable energy, robotization), farmlands consolidation and enhancement, infrastructural amelioration, organizational restructuring, etc.

Not least important, the failures of government bureaucrats to foresee, prevent, communicate, and deal with the March 2011 disaster and its consequences have thought individual agents to take decentralized actions – self-recovery and reconstruction, community and business initiatives, private and collective safety checks and decontamination measures, voluntary shipment restrictions, new production and marketing methods, movements for fundamental policies change, etc.

Understandably the research on the multiple impacts of the triple disater is incomplete due to the "short" period of time after the disasters, insufficient and controversial data, difficulties to adequately assess longer term implications, etc. Therefore, more future studies are necessary to evaluate and update the "known" agricultural and food impacts of the 2011 disasters. Besides, further in depth "micro" studies are needed to fully understand and estimate the impacts of the disasters in each location and community, type of farms and productions, and component of agri-food chain.

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