Article

Decomposition Analysis of Global Water Supply-Demand Balances Focusing on Food Production and Consumption

Yohei Yamaguchi ^{1,*}, Naoki Yoshikawa ², Koji Amano ³ and Seiji Hashimoto ²

¹ Graduate School of Science and Engineering, Ritsumeikan University, Kusatsu 525-8577, Japan

² College of Science and Engineering, Ritsumeikan University, Kusatsu 525-8577, Japan; n-yoshik@fc.ritsumei.ac.jp (N.Y.); shashimo@fc.ritsumei.ac.jp (S.H.)

³ College of Gastronomy Management, Ritsumeikan University, Kusatsu 525-8577, Japan; amano@se.ritsumei.ac.jp

* Correspondence: y-ymagch@fc.ritsumei.ac.jp

Abstract: Food production and consumption require large amounts of freshwater. There is no literature on the decomposition analysis of the intensities of water supply-demand balances (water balance intensities) for each country worldwide. The aim of this study is to evaluate the water balance intensities and elucidate the promoting factors and offset factors of water balance intensities for each country worldwide, focusing on food supply-demand balances and considering food trade balances on a global scale. The modified Laspeyres index method is applied to both a production-based water balance index (WBI^{PB}) and a consumption-based water balance index (WBI^{CB}). The major promoting factor for the WBI^{PB} is the renewable freshwater resources, whereas the major offset factor is the produced item preference. The major promoting factor for the WBI^{CB} is the consumed item preference, whereas the major offset factor is the producing area preference. Improving irrigation efficiencies of rice and cereals is effective because rice requires the largest blue water footprint intensities, considering irrigation efficiency on a calorie content basis in all of the items, whereas cereals are the largest share of calorie-based production quantities in all of the items worldwide. This study provides the foundation for decreasing water balance intensities regarding food production and consumption.

Keywords: water balance index; modified Laspeyres index method; water footprint; blue water; food supply-demand balances; global analysis

Citation: Yamaguchi, Y.; Yoshikawa, N.; Amano, K.; Hashimoto, S. Decomposition Analysis of Global Water Supply-Demand Balances Focusing on Food Production and Consumption. *Sustainability* **2021**, *13*, 7586. <https://doi.org/10.3390/su13147586>

Academic Editor: Ali Torabi Haghighi

Received: 13 May 2021

Accepted: 30 June 2021

Published: 7 July 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Food production and consumption are essential for human life but require large amounts of freshwater. The agricultural sector consumes the largest amount of water (2658 km³/year), accounting for approximately 70% of the global total water withdrawal [1]. However, freshwater resources tend to be unevenly distributed in water-rich regions worldwide. It is said that the direct trade of freshwater resources between water-rich and water-poor regions is impossible due to the costs incurred in long-distance transportation [2]. Thus, trading food could be an important option for water-poor regions to compensate for their food shortage, which leads to an unintentional increase in freshwater requirements for food-producing regions.

The International Organization for Standardization introduced the concept of water footprint, which makes it possible to quantify the potential impact of water use and pollution based on the idea of a life cycle assessment [3]. Most goods and services are consumed by households, businesses, and offices at the final demand stages and finally arrive at the end-of-life stages via raw material, processing, distribution, and retail sale stages. The water requirements of goods and services are estimated by summarizing the water consumption for all stages. The Water Footprint Network proposed three types of water footprint: green, blue, and gray [4]. Green water originates from precipitation, does

not run off and is not immediately restored to surface water and groundwater. Some of the restored water is consumed as blue water, which is artificially supplied as irrigation water to compensate for the shortfalls in green water. Gray water is the hypothetical volume of freshwater required to dilute the pollutant loads in existing ambient water quality standards to natural background concentrations [4]. To evaluate water supply-demand balances, a water stress index is defined as the ratio of annual water withdrawals to annual renewable water resources [5], and it has been used in many previous studies and defined in various forms [6,7]. Blue water is used to evaluate the water stress index [8]. Water stress is generally suitable for the evaluation of water demand on a production basis and is unsuitable for that on a consumption basis.

Decomposition analysis is a useful tool for elucidating the factors of change between two periods or objects. There are two techniques for decomposition analyses: index decomposition analysis (IDA) and structure decomposition analysis (SDA). The former is applied to aggregate data at the sector level, whereas the latter is applied to the input-output model [9]. It is important to improve the problem of residual terms, interpreted as the amount of change between two or more factors, to show a reliable decomposition result. As perfect decomposition techniques, various models have been proposed in the literature, such as the log-mean Divisia index (LMDI) method I and II [10], refined Laspeyres index (RLI) method [11–13], and modified Laspeyres index (MLI) method [14,15]. Based on the assumption that there is no residual term and the factors of change are only time-dependent, the LMDI method is often used. In contrast, the RLI method is fairly complex when applied to more than two factors [16]. In addition, it has the over- or under-estimation problems caused by the attribution and distribution methods of residual terms [14,15]. Although the MLI method has limitations of the same complicity as the RLI method, it can be applied to negative values and to improve the attribution and distribution problems of the RLI method.

In the aforementioned methods, IDA and SDA are commonly used together when evaluating the water footprint. The LMDI method, a type of IDA, was used to analyze changes in the water footprint of crop production in Beijing [17], in the driving force analysis of the agricultural water footprint in China [18], and to estimate regional irrigation water demand and driving factor effects in the Heihe River basin [19]. The SDA was used to analyze changes in Beijing's water footprint [20], changes in the sectoral water footprint in China [21], and the driving force of the water footprint under the rapid urbanization process for Zhangye City in China [22]. The SDA was also applied to identify the hydro-climatic and socioeconomic forces of water scarcity in Beijing [23]. All the studies cited here were based on temporal data during specific periods. Studies have been conducted on the spatial decomposition analysis of water intensity in China [24]. To the best of the author's knowledge, there is no literature on the decomposition analysis of the intensities of water supply-demand balances (water balance intensities) for each country worldwide, focusing on food supply-demand balances and considering food trade balances on a global scale.

This study aims to evaluate water balance intensities and elucidate the promoting and offset factors of water balance intensities for each country on a global scale. This study provides the foundation for decreasing water balance intensities regarding food production and consumption based on water resource management.

2. Materials and Methods

2.1. Food Supply-Demand Balances Considering Food Trade Balances

The equation for food supply-demand balances is as follows:

$$PRO_{cj} + IQ_{cj} + SV_{cj} = DSQ_{cj} + EQ_{cj}, \quad (1)$$

where subscripts c and j represent the target country and food item, respectively. PRO_{cj} is the production quantity, IQ_{cj} is the import quantity, SV_{cj} is the amount of stock variation, DSQ_{cj} is the domestic supply quantity, and EQ_{cj} is the export quantity of item j for country c . IQ_{cj} is the sum of IQ_{ijk} in producing country k , whereas EQ_{cj} is the sum of EQ_{ijk} in

consuming country i . Raw data of each category are used after calculating the three-year average from 2009 to 2011 to employ as the yearly reference data for each category. Here, IQ_{ijk} and EQ_{ijk} are taken from the food trade balance matrices for each item, which were calculated in our previous study [25]. Before calculating IQ_{cj} and EQ_{cj} , each component of the food trade balance matrices is adjusted by using the RAS method [26] to match the sum of import quantities with that of export quantities for each food item on a global scale.

In the commodity balance sheets of the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT), DSQ_{cj} is the sum of six consumption categories: feed, processed materials, losses, food supply quantities, seeds, and other uses [27]. In this study, feed and processed materials are considered as intermediate demands, whereas food supply quantities and losses are classified into final demands and composed of food consumption. Losses are interpreted as losses caused during storage or technical losses caused when transforming the primary commodities into processed products, excluding losses occurring during the pre-harvest and harvesting stages and deriving from edible or inedible waste in the household [27]. Seeds are the amounts of the commodity used for reproductive purposes, such as seed of sugarcane plant, hatching eggs, and fish bait [27]. Other uses include the amounts of the commodity mainly consumed by tourists and used for manufacturing in non-food purposes such as oil for soap [27].

2.2. Production-Based and Consumption-Based Blue Water Requirements

In this study, only blue water is targeted. Surface and ground water play a role of a supply source of blue (irrigation) water to supplement the shortage of green water (rainwater). From this viewpoint, focusing on blue water requirements is suitable to simulate water balance intensities. Thus, green water is excluded from the evaluation target. The blue water requirement is calculated in two manners: a blue water requirement on a production basis and a consumption basis (WR^{PB} and WR^{CB} , respectively) defined as follows:

$$WR^{PB}_{kj} = PRO_{kj} \times \frac{WFI_{kj}}{IRE_{kj}} \quad (2)$$

$$WR^{CB}_{ijk} = COM_{ijk} \times \frac{WFI_{kj}}{IRE_{kj}}, \quad (3)$$

where superscripts PB and CB represent production-based simulation and consumption-based simulation, respectively. WR^{PB}_{kj} is the WR^{PB} , PRO_{kj} is the production quantity, WFI_{kj} is the water footprint intensity, and IRE_{kj} is the irrigation efficiency of item j for producing country k . In Equation (3), WR^{CB}_{ijk} is the WR^{CB} and COM_{ijk} is the food consumption of item j between consuming country i and producing country k .

COM_{ijk} is classified into two patterns based on the relationship between consuming country i and producing country k , namely, $i = k$ and $i \neq k$:

$$COM_{ijk} = PRO_{ij} + SV_{ij} - FE_{ij} - PRC_{ij} - SE_{ij} - OU_{ij} \quad (i = k) \quad (4)$$

$$COM_{ijk} = IQ_{ijk} - EQ_{ijk} \quad (i \neq k), \quad (5)$$

where PRO_{ij} is the production quantity, SV_{ij} is the amount of stock variation, FE_{ij} is the amount of feed, PRC_{ij} is the amount of processed materials, SE_{ij} is the amount of seeds, and OU_{ij} is the amount of other uses of item j for consuming country i . Here, $(IQ_{ijk} - EQ_{ijk})$ is defined as the net trade quantity calculated by subtracting the export quantity from the import quantity for each country on a per capita basis. The net import and export quantities are defined as $(IQ_{ijk} - EQ_{ijk})$ with $IQ_{ijk} \geq EQ_{ijk}$ and $IQ_{ijk} < EQ_{ijk}$, respectively. If $IQ_{ijk} \geq EQ_{ijk}$, the water footprint intensity of production countries is applied to WFI_{ijk} ; otherwise ($IQ_{ijk} < EQ_{ijk}$), that of consumption countries is applied to WFI_{ijk} . The irrigation efficiency is evaluated in the same way as the WR^{PB} .

For agricultural crops, only direct water consumption during the cultivation stage is included. For livestock products, direct water consumption during the rearing stage of

livestock, such as drinking water and service water to maintain a rearing environment, and feed crops for livestock during the cultivation stage are included. These stages consist of a system boundary for water footprint simulation. Here, the aforementioned types of water consumption are originally included in the water footprint intensities. The intermediate demand composed of feed and processed materials is excluded from our simulation because an overestimation could be caused by a double counting of the water footprint. Thus, the final demand, composed of food supply quantities and losses, is targeted. In addition, seeds and other uses are excluded from the simulation because seeds are considered as a type of upstream indirect water consumption during the cultivation stage for each agricultural crop, and other uses are not inconsistent in the system boundary. Thus, feed, processed materials, seed, and other uses are subtracted from the sum of production quantities and the amount of stock variation in the Equation (4).

WFI_{kj} and IRE_{kj} mainly refer to the literature values (Refs. [28,29], respectively) of item j for the producing country or for area k . Missing data on WFI_{kj} are replaced with the water footprint intensities of neighboring countries for each item, simple average values of 23 regions for each item, calculated using the literature values for the applicable countries, or literature values of the world average for each item [28]. IRE_{kj} for rice is uniformly set as 1.0, whereas IRE_{kj} for non-rice items is set as the irrigation efficiency of non-rice items for each region. IRE_{kj} of Middle Africa and North America are set as irrigation efficiencies on a simple regional average for each applicable area. To avoid overestimation due to transit trades, the exported blue water footprint intensity of item j for consuming country i on a weighted average is defined. The weights are the production and net import quantities of item j for producing country k .

2.3. Production-Based and Consumption-Based Water Balances Indices

In this study, water balance intensities are evaluated by using two water balance indices: a production-based water balance index (WBI^{PB}) and a consumption-based water balance index (WBI^{CB}). The former can evaluate water balance intensities based on production by assigning water requirements to producing countries, whereas the latter can evaluate water balance intensities based on consumption by assigning water requirements to consuming countries. Consumption is roughly calculated by adding production and subtracting exports from imports. Based on a comparison between the two indices, it is expected that the difference in water balance intensities between the production and consumption sides can be quantitatively evaluated.

The WBI^{PB} and WBI^{CB} are defined as follows:

$$WBI^{PB}_k = \frac{\sum_j (WR^{PB}_{kj})}{TRWR_k \times \frac{AWW_k}{TWW_k}} \quad (6)$$

$$WBI^{CB}_i = \frac{\sum_k \sum_j (WR^{CB}_{ijk})}{TRWR_i \times \frac{AWW_i}{TWW_i}}, \quad (7)$$

where WBI^{PB}_k is the WBI^{PB} of producing country k , and WBI^{CB}_i is the WBI^{CB} of consuming country i . $TRWR_k$ and $TRWR_i$ are the total renewable water resources ($TRWR$'s) of producing country k and consuming country i , respectively. AWW_k and AWW_i are the agricultural water withdrawal (AWW) of producing country k and consuming country i , respectively. TWW_k and TWW_i are the total water withdrawal (TWW) of producing country k and consuming country i , respectively. For the $TRWR$'s, AWW , and TWW , missing data are replaced with data from the nearest period of the reference year (2010). Countries with no data for the nearest period are excluded from the target countries of this study.

WBI^{PB}_k and WBI^{CB}_i are evaluated in terms of five intensity categories as follows: very low intensity ($WBI < 0.1$), low intensity ($0.1 \leq WBI < 0.2$), moderate intensity ($0.2 \leq WBI < 0.4$), high intensity ($0.4 \leq WBI < 0.8$), and very high intensity ($WBI \geq 0.8$).

The five intensity categories of both indices follow those of the water stress index in a previous study [30].

2.4. Decomposition Analysis of Production-Based and Consumption-Based Water Balances Indices

2.4.1. Decomposed Factors of Production-Based Water Balance Index

To conduct a decomposition analysis, the difference in the WBI^{PB} between each country's value and the standard value is defined as follows:

$$\begin{aligned}\Delta WBI^{PB}_k &= WBI^{PB}_k - WBI^{PB}_{0k} \\ &= \sum_j^{N_{jk}} \left(\Delta WBI^{PB}_{kj1} + \Delta WBI^{PB}_{kj2} + \Delta WBI^{PB}_{kj3} + \Delta WBI^{PB}_{kj4} + \Delta WBI^{PB}_{kj5} \right),\end{aligned}\quad (8)$$

where subscript zero represents the standard value. ΔWBI^{PB}_k is the difference in the WBI^{PB} for producing country k , and WBI^{PB}_{0k} is the standard value of the WBI^{PB} for producing country k . ΔWBI^{PB}_{kjin} ($n = 1, 2, 3, 4, 5$, where n is the number of factors) is the decomposed factor of item j for producing country k . Each factor is defined as follows: ΔWBI^{PB}_{kj1} is a renewable freshwater resources factor ($\Delta F1_PB$); ΔWBI^{PB}_{kj2} is an industrial structure factor ($\Delta F2_PB$); ΔWBI^{PB}_{kj3} is a production scale factor ($\Delta F3_PB$); ΔWBI^{PB}_{kj4} is a produced item preference factor ($\Delta F4_PB$); and ΔWBI^{PB}_{kj5} is a water footprint intensity factor ($\Delta F5_PB$). If $\Delta WBI^{PB}_{kjin} \geq 0$, this factor is seen as a promoting factor for water balance intensities (promoting factor); otherwise ($\Delta WBI^{PB}_{kjin} < 0$), this factor is seen as offset for water balance intensities (offset factor).

WBI^{PB}_k is decomposed into five factors as follows:

$$WBI^{PB}_k = \frac{1}{TRWR_k} \times \frac{TW W_k}{AW W_k} \times WR^{PB}_k \quad (9)$$

$$WR^{PB}_k = \sum_j^{N_{jk}} \left(PRO^{CAL}_k \times \frac{PRO^{CAL}_{kj}}{PRO^{CAL}_k} \times \frac{WFI_{kj}}{UCF_j \times IRE_{kj}} \right), \quad (10)$$

where superscript CAL indicates a calorie-based conversion. PRO^{CAL}_k is the calorie-based production quantity of producing country k , PRO^{CAL}_{kj} is the calorie-based production quantity of item j for producing country k , and UCF_j is the calorie conversion factor of item j . In Equations (9) and (10), all of the right terms except for the third term of Equation (10) are calculated on a per capita basis. Each term in both equations is interpreted as follows: $(1/TRWR_k)$ is the multiplicative number of the $TRWR$'s related to $\Delta F1_PB$; $(TW W_k/AW W_k)$ is the multiplicative inverse of the ratio of AWW to TWW (agricultural withdrawal rate) related to $\Delta F2_PB$; PRO^{CAL}_k is the calorie-based production quantity related to $\Delta F3_PB$; $(PRO^{CAL}_{kj}/PRO^{CAL}_k)$ is the produced item's share related to $\Delta F4_PB$; and $(WFI_{kj}/UCF_j/IRE_{kj})$ is the water footprint intensity per calorie content considering the irrigation efficiency related to $\Delta F5_PB$.

Calorie conversion factors for 11 items ("Cereals, Other", "Roots, Other", "Sweeteners, Others", "Pluses, Other and products", "Oilcrops, Other", "Oilcrops Oil, Other", "Vegetables, Other", "Citrus, Other", "Fruits, Other", "Spices, Other", and "Meat, Other" in the FAOSTAT) are set as a median of calorie conversion factors for each applicable item. Calorie conversion factors for meats are set as a weighted average of the calorie conversion factor whose weight is the amount of distribution for each applicable meat. The meat distribution is calculated by multiplying the amount of distribution by cuts of meat by the population of Japan. The calorie conversion factors for mutton and goat meat are calculated by the calorie conversion factor for lamb meat by cuts of a part on a simple average due to the lack of data on the amount of distribution for both items.

WBI^{PB}_{0k} is calculated as follows:

$$WBI^{PB}_{0k} = \frac{1}{TRWR_0} \times \frac{TWW_0}{AWW_0} \times WR^{PB}_{0k} \quad (11)$$

$$WR^{PB}_{0k} = \sum_j^{N_{jk}} \left(PRO^{CAL}_0 \times \frac{PRO^{CAL}_{0jk}}{PRO^{CAL}_0} \times \frac{WFI_{0j}}{UCF_j \times IRE_{0j}} \right), \quad (12)$$

where $TRWR_0$ is the standard value of $TRWR$'s and calculated by dividing the sum of $TRWR$'s for all countries based on the FAO's Global Information System on Water and Agriculture (AQUASTAT) by the global population. AWW_0 is the standard value of AWW and calculated by dividing the sum of AWW 's for all countries based on the AQUASTAT by the global population. TWW_0 is the standard value of TWW and calculated by dividing the sum of the TWW 's for all countries based on the AQUASTAT by the global population. PRO^{CAL}_0 and PRO^{CAL}_{0jk} are the standard values of the calorie-based production quantities and that of item j for producing country k , respectively. The former is calculated by adding the calorie-based production quantities for all countries by the global population, whereas the latter is calculated by that of item j for all countries. WFI_{0j} refers to the literature values [28]. IRE_{0j} is the irrigation efficiency on a simple world average and calculated using the literature values for all areas [29]. Here, the correction factor is defined as the ratio of the global population of $\Delta F3_PB$ to that of $\Delta F1_PB$, which is multiplied by $\Delta F1_PB$ to correct the error of $\Delta F1_PB$. This error could result from the difference in the global population of $\Delta F1_PB$ and that of $\Delta F3_PB$. The global population of $\Delta F4_PB$ is equal to that of $\Delta F3_PB$. Finally, nearly 70% of all WBI^{PB}_{0k} exist at 0.079 ± 0.033 .

2.4.2. Decomposition Factors of Consumption-Based Water Balance Index

To conduct a decomposition analysis, the difference in the WBI^{CB} for each country's value and the standard value is defined as follows:

$$\begin{aligned} \Delta WBI^{CB}_i &= WBI^{CB}_i - WBI^{CB}_{0i} \\ &= \sum_k^{N_{ijk}} \sum_j^{N_{ij}} \left(\Delta WBI^{CB}_{ijk1} + \Delta WBI^{CB}_{ijk2} + \Delta WBI^{CB}_{ijk3} + \Delta WBI^{CB}_{ijk4} + \Delta WBI^{CB}_{ijk5} + \Delta WBI^{CB}_{ijk6} \right), \end{aligned} \quad (13)$$

where ΔWBI^{CB}_i is the difference in the WBI^{CB} for consuming country i and WBI^{CB}_{0k} is the standard value of the WBI^{CB} for producing country k . ΔWBI^{CB}_{ijkn} ($n = 1, 2, 3, 4, 5, 6$) are six decomposed factors of item j between consuming country i and producing country k . Each factor is defined as follows: ΔWBI^{CB}_{ijk1} is a renewable freshwater resources factor ($\Delta F1_CB$); ΔWBI^{CB}_{ijk2} is an industrial structure factor ($\Delta F2_CB$); ΔWBI^{CB}_{ijk3} is a consumption scale factor ($\Delta F3_CB$); ΔWBI^{CB}_{ijk4} is a consumed item preference factor ($\Delta F4_CB$); ΔWBI^{CB}_{ijk5} is a producing area preference factor ($\Delta F5_CB$); and ΔWBI^{CB}_{ijk6} is a water footprint intensity factor ($\Delta F6_CB$). If $\Delta WBI^{CB}_{ijkn} \geq 0$, this factor is seen as a promoting factor; otherwise ($\Delta WBI^{CB}_{ijkn} < 0$), it is seen as an offset factor.

WBI^{CB}_i is decomposed into six factors as follows:

$$WBI^{CB}_i = \frac{1}{TRWR_i} \times \frac{TWW_i}{AWW_i} \times WR^{CB}_i \quad (14)$$

$$WR^{CB}_i = \sum_k^{N_{ijk}} \sum_j^{N_{ij}} \left(COM^{CAL}_i \times \frac{COM^{CAL}_{ij}}{COM^{CAL}_i} \times \frac{COM^{CAL}_{ijk}}{COM^{CAL}_{ij}} \times \frac{WFI_{ij}}{UCF_j \times IRE_{ij}} \right), \quad (15)$$

where COM^{CAL}_i is the amount of calorie-based consumption of consuming country i , COM^{CAL}_{ij} is the amount of calorie-based consumption of item j for consuming country i , and COM^{CAL}_{ijk} is the amount of calorie-based consumption of item j between consuming country i and producing country k . In Equations (14) and (15), all of the right terms except for the fourth term of Equation (15) are calculated on a per capita basis. Each factor

term in Equations (14) and (15) is interpreted as follows: $(1/TRWR_i)$ is the multiplicative inverse of the $TRWR$'s related to $\Delta F1_CB$; (TWW_i/AWW_i) is the multiplicative inverse of the agricultural withdrawal rate related to $\Delta F2_CB$; COM^{CAL}_i is the calorie-based food consumption related to $\Delta F3_CB$; $(COM^{CAL}_{ij}/COM^{CAL}_i)$ is the consumed item's share related to $\Delta F4_CB$; $(COM^{CAL}_{ijk}/COM^{CAL}_{ij})$ is the producing country's share related to $\Delta F5_CB$; and $(WFI_{kj}/UCF_j/IRE_{kj})$ is the water footprint intensity per calorie content considering the irrigation efficiency related to $\Delta F6_CB$.

WBI^{CB}_{0i} is calculated as follows:

$$WBI^{CB}_{0i} = \frac{1}{TRWR_0} \times \frac{TWW_0}{AWW_0} \times WR^{CB}_{0i} \quad (16)$$

$$WR^{CB}_{0i} = \sum_k \sum_j^{N_{ijk}} \left(COM^{CAL}_0 \times \frac{COM^{CAL}_{0j}}{COM^{CAL}_0} \times \frac{COM^{CAL}_{0jk}}{COM^{CAL}_{0j}} \times \frac{WFI_{0j}}{UCF_j \times IRE_{0j}} \right), \quad (17)$$

where $TRWR_0$, AWW_0 , and TWW_0 are calculated in the same manner as in the aforementioned WBI^{PB} simulation. COM^{CAL}_0 is the standard value of calorie-based consumption and calculated by adding the calorie-based consumption for all countries by the global population. COM^{CAL}_{0j} and COM^{CAL}_{0jk} are the standard values of the calorie-based consumption of item j and that of item j for consuming country k , respectively. The former is calculated by adding the calorie-based consumption of item j for all countries by the global population, whereas the latter is calculated by that of item j for producing country k . Here, the error of $\Delta F1_CB$ is calculated in the same way as in the aforementioned WBI^{PB} simulation. The global population of $\Delta F4_CB$ or $\Delta F5_CB$ is equal to that of $\Delta F3_CB$. Finally, nearly 70% of all WBI^{CB}_{0i} exist at 0.086 ± 0.0015 .

2.4.3. Complete Decomposition Analysis

In this study, the MLI method [14,15] is applied to both the WBI^{PB} and WBI^{CB} to consider the residual terms for calculating contribution factors. If the factors of positive change and those of negative change are simultaneously mixed in an interaction term, the interaction term is attributed to only the former term related to them. If an interaction term consists of factors of positive or negative change not simultaneously mixed with each other, the interaction term is attributed to their related factors.

In the case of the WBI^{CB} , first, the MLI method is applied to $\Delta WR^{CB}_{ijk} = WR^{CB}_{ijk} - WR^{CB}_{0jk}$. Here, ΔWR^{CB}_{ijk} is decomposed into four factors (ΔWR^{CB}_{ijk1} , ΔWR^{CB}_{ijk2} , ΔWR^{CB}_{ijk3} , and ΔWR^{CB}_{ijk4}) and is equal to the sum of these four factors. Thus, ΔWR^{CB}_{ijk1} is calculated as follows:

$$\begin{aligned} \Delta WR^{CB}_{ijk1} = & \Delta x_1 x_{02} x_{03} x_{04} + \frac{a_1}{a_1+a_2} \Delta x_1 \Delta x_2 x_{03} x_{04} + \frac{a_1}{a_1+a_3} \Delta x_1 x_{02} \Delta x_3 x_{04} \\ & + \frac{a_1}{a_1+a_4} \Delta x_1 x_{02} x_{03} \Delta x_4 + \frac{a_1}{a_1+a_2+a_3} \Delta x_1 \Delta x_2 \Delta x_3 x_{04} + \frac{a_1}{a_1+a_2+a_4} \Delta x_1 \Delta x_2 x_{03} \Delta x_4 \\ & + \frac{a_1}{a_1+a_3+a_4} \Delta x_1 x_{02} \Delta x_3 \Delta x_4 + \frac{a_1}{a_1+a_2+a_3+a_4} \Delta x_1 \Delta x_2 \Delta x_3 \Delta x_4. \end{aligned} \quad (18)$$

Here, Δx_m and a_m are defined as follows:

$$\Delta x_m = x_m - x_{0m} \quad (m = 1, 2, 3, 4) \quad (19)$$

$$a_m = \frac{\Delta x_m}{\frac{x_m + x_{0m}}{2}} \quad (m = 1, 2, 3, 4), \quad (20)$$

where x_m is the m th factor for the consuming country, item, and producing country (omitted respective subscripts i , j , and k), and x_{0m} is the standard value of the m th factor. The value of a_m with $\Delta x_m < 0$ is set to zero as long as the total number of a_m with an allocation coefficient of $\Delta x_m < 0$ is less than that of the denominator of the allocation factor. If all of the variables of Δx_m are negative values, each allocation coefficient is replaced with the difference between one and itself, and a_m with $\Delta x_m < 0$ is not set to zero. For example,

allocation coefficients $\{a_1/(a_1 + a_2)\}$, $\{a_1/(a_1 + a_2 + a_3)\}$, and $\{a_1/(a_1 + a_2 + a_3 + a_4)\}$ are replaced with $\{1 - a_1/(a_1 + a_2)\}$, $\{1 - (1/2) \times a_1/(a_1 + a_2 + a_3)\}$, and $\{1 - (1/3) \times a_1/(a_1 + a_2 + a_3 + a_4)\}$, respectively. The same is true for ΔWR^{CB}_{ijk2} to ΔWR^{CB}_{ijk4} . It should be noted that each substitution formula of weight coefficients with over three a_m is uniquely formulated by referring to the literature [14,15].

Second, ΔWBI^{CB}_{ijk} is decomposed into three factors (ΔWBI^{CB}_{ijk1} , ΔWBI^{CB}_{ijk2} , and ΔWBI^{CB}_{ijkWR} ; ΔWBI^{CB}_{ijkWR} is a water requirement factor) as follows:

$$\Delta WBI^{CB}_{ijk1} = \Delta y_1 y_{02} y_{0WR} + \frac{b_1}{b_1 + b_2} \Delta y_1 \Delta y_2 y_{0WR} + \frac{b_1}{b_1 + b_{WR}} \Delta y_1 y_{02} \Delta y_{WR} + \frac{b_1}{b_1 + b_2 + b_{WR}} \Delta y_1 \Delta y_2 \Delta y_{WR} \quad (21)$$

$$\Delta WBI^{CB}_{ijk2} = y_{01} \Delta y_2 y_{0WR} + \frac{b_2}{b_1 + b_2} \Delta y_1 \Delta y_2 y_{0WR} + \frac{b_2}{b_2 + b_{WR}} y_{01} \Delta y_2 \Delta y_{WR} + \frac{b_2}{b_1 + b_2 + b_{WR}} \Delta y_1 \Delta y_2 \Delta y_{WR} \quad (22)$$

$$\Delta WBI^{CB}_{ijkWR} = y_{01} y_{02} \Delta y_{WR} + \frac{b_{WR}}{b_1 + b_{WR}} \Delta y_1 y_{02} \Delta y_{WR} + \frac{b_{WR}}{b_2 + b_{WR}} y_{01} \Delta y_2 \Delta y_{WR} + \frac{b_{WR}}{b_1 + b_2 + b_{WR}} \Delta y_1 \Delta y_2 \Delta y_{WR}. \quad (23)$$

Here, Δy_n and b_n are defined as follows:

$$\Delta y_n = y_n - y_{0n} \quad (n = 1, 2, WR) \quad (24)$$

$$b_n = \frac{\Delta y_n}{\frac{y_n + y_{0n}}{2}} \quad (n = 1, 2, WR), \quad (25)$$

where y_n is the n th factor ($n = 1, 2$) or factor of the WR^{CB} ($n = WR$) for the consuming country, item, and producing country (omitted respective subscripts i, j , and k). y_{0n} is the standard value of the n th factor ($n = 1, 2$) or factor of the WR^{CB} ($n = WR$). Each b_n is calculated in the same way as in the aforementioned description. If all Δy_n are negative values, each allocation coefficient is replaced with the difference between one and itself, and b_n when $\Delta y_n < 0$ is not set to zero. In Equation (21), allocation coefficients $\{b_1/(b_1 + b_2)\}$, $\{b_1/(b_1 + b_{WR})\}$, and $\{b_1/(b_1 + b_2 + b_{WR})\}$ are replaced with $\{1 - b_1/(b_1 + b_2)\}$, $\{1 - b_1/(b_1 + b_{WR})\}$, and $\{1 - (1/2) \times b_1/(b_1 + b_2 + b_{WR})\}$, respectively. It should be noted that each substitution formula of weight coefficients composed of three b_n is uniquely formulated by referring to the literature [14,15].

Finally, substituting ΔWR^{CB}_{ijk} for Δy_{WR} enables ΔWBI^{CB}_{ijk} to be decomposed into six factors (from $\Delta F1_CB$ to $\Delta F6_CB$) by rearranging each term of Equations (21)–(23) to satisfy Equation (13).

In the case of the WBI^{PB} , ΔWBI^{PB}_{ijk} is decomposed into five factors (from $\Delta F1_PB$ to $\Delta F5_PB$) by changing from Equation (18) with four factors to an equation with three factors (the same form as Equation (21)) regarding ΔWBI^{PB}_{ijk1} . The same is true for ΔWBI^{PB}_{ijk2} and ΔWBI^{PB}_{ijk3} .

For both the WBI^{PB} and WBI^{CB} , the total number of samples is different for each country. The total numbers of samples for the WBI^{PB} and WBI^{CB} are shown in Tables A1 and A2 (Appendix A), respectively. In other words, some of the samples are excluded from the decomposition analysis targets when either their numerators or denominators are equal to zero.

2.5. Study Target and Usage Data

In this study, the target year is set to 2010 to use simulation data of import and export quantities obtained from our previous study [15]. In addition, 175 countries and 78 food items are targeted by referring to the commodity balance sheets of the FAOSTAT [31,32]. Only mainland China is embodied as China, and Hong Kong SAR, Macao SAR, and Taiwan Province are handled as trade partner countries. For the water supply-demand balances and decomposition analysis, 156 countries are targeted. Two countries (Maldives and Saint Vincent and the Grenadines) are excluded from both analyses because their AWW's are zero, and therefore, their WBI^{PB} and WBI^{CB} values diverge to positive infinity. In addition,

17 countries are excluded due to the lack of data on any of the $TRWR$'s, AWW 's, and TWW 's. However, these 19 countries only include the trade partner total of 156 nations.

For the food supply-demand balances, the production and domestic supply quantities for each country and item refer to the commodity balance table of the FAOSTAT [31,32]. The import and export quantities for each country and item refer to the commodity balance sheets [31,32] and the detailed trade matrix of the FAOSTAT [33]. For the WR^{PB} and WR^{CB} , the water footprint intensity and irrigation efficiency for each country and item are the literature values ([28,29], respectively). For both the WBI^{PB} and WBI^{CB} , the $TRWR$'s, AWW , and TWW for each country refer to AQUASTAT [34]. For the decomposition analysis, the calorie conversion factor mainly refers to the Standard Tables of Food Composition in Japan in the reference year [35], and missing data are replaced with that the data of 2015 [36]. The calorie conversion factors for items applied to the median refer to several statistical databases [35–38] and the literature value [39]. The amount of distribution by cuts of meat refers to the statistical data [40]. Population data are obtained from the demographic data of the FAOSTAT [41].

3. Results

3.1. Comparing Production-Based and Consumption-Based Water Balance Indices

As shown in Figure 1a, 58 countries from the moderate to very high intensity regions based on the WBI^{PB} tend to be distributed around the mid-latitude regions, such as arid regions, large population regions, and industrialized countries. In contrast, Figure 1b shows that 72 countries from the moderate to very high intensity regions based on the WBI^{CB} tend to be concentrated in Northern Europe, Africa, Central Asia, Western Asia, and several island countries around Africa and the Caribbean region.

A comparison of the intensities between the WBI^{PB} and WBI^{CB} shows that the former is higher for 17 countries, whereas the latter is higher for 36 countries. In addition, 103 countries are approximately the same, including 40 countries from the moderate to very high intensity regions. For example, China's WBI^{PB} is 0.49 and WBI^{CB} is 0.38, and the United States of America's WBI^{PB} is 0.20 and WBI^{CB} 0.096. The intensities of the WBI^{PB} can increase because of food production for export. In contrast, the United Kingdom has a WBI^{PB} of 0.16 and WBI^{CB} of 0.61, and South Africa has a WBI^{PB} of 0.29 and WBI^{CB} of 0.43. The intensities of the WBI^{CB} tend to rise due to their food trade, and they can increase the water balance intensities of producing countries through their food imports.

3.2. Comparing Decomposition of Production-Based and Consumption-Based Water Balance Indices

Figure 2a–c shows the number of countries based on the five promoting factors and five offset factors of the WBI^{PB} . There are 98 countries in the very low or low intensity regions, 16 countries in the moderate intensity region, and 42 countries in the high or very high intensity regions. In the very low or low intensity regions, $\Delta F1_PB$ is the major promoting factor for 31 countries, followed by $\Delta F2_PB$ for 30 countries, and $\Delta F4_PB$ for 19 countries. In the moderate-intensity region, $\Delta F1_PB$ and $\Delta F2_PB$ are tied for six countries and are relatively large promoting factors, followed by $\Delta F4_PB$ and $\Delta F5_PB$ for two countries in a tie. In the high or very high intensity regions, 20 countries have $\Delta F1_PB$ as the major promoting factor, followed by $\Delta F5_PB$ for ten countries, and $\Delta F2_PB$ and $\Delta F4_PB$ for five countries in a tie.

Figure 1. Global distribution map for two water balance indices: (a) WBI^{PB} ; (b) WBI^{CB} . Note: WBI^{PB} is the production-based water balance index, and WBI^{CB} is the consumption-based water balance index. Each color represents as follows: “Red”: very high intensity, “Orange”: high intensity, “Yellow”: moderate intensity, “Green”: low intensity, “Blue”: very low intensity, and “Gray” is excluded countries from both WBI^{PB} and WBI^{CB} analyses.

Figure 2. Number of countries based on (a–c) five promoting factors and five offset factors of WBI^{PB} , and (d–f) six promoting factors and six offset factors of WBI^{CB} : (a,d) in the very low or low intensity regions; (b,e) in the moderate intensity region; and (c,f) in the high or very high intensity regions. Note: Five factors for WBI^{PB} are defined as follows: $\Delta F1_{PB}$ is the renewable freshwater resources factor, $\Delta F2_{PB}$ is the industrial structure factor, $\Delta F3_{PB}$ is the production scale factor, $\Delta F4_{PB}$ is the produced item preference factor, and $\Delta F5_{PB}$ is the water footprint intensity factor. Six factor for WBI^{CB} are defined as follows: $\Delta F1_{CB}$ is the renewable freshwater resources factor, $\Delta F2_{CB}$ is the industrial structure factor, $\Delta F3_{CB}$ is the consumption scale factor, $\Delta F4_{CB}$ is the consumed item preference factor, $\Delta F5_{CB}$ is the producing area preference factor, and $\Delta F6_{CB}$ is the water footprint intensity factor. Each factor of WBI^{PB} (from $\Delta F1_{PB}$ to $\Delta F5_{PB}$) and of WBI^{CB} (from $\Delta F1_{CB}$ to $\Delta F6_{CB}$) is aggregated by the summation of item j for each country and for each n . Vertical axis shows five (from $\Delta F1_{PB_PRO}$ to $\Delta F5_{PB_PRO}$ for WBI^{PB}) or six (from $\Delta F1_{CB_PRO}$ to $\Delta F6_{CB_PRO}$ for WBI^{CB}) promoting factors. Explanatory note shows five (from $\Delta F1_{PB_OFF}$ to $\Delta F5_{PB_OFF}$ for WBI^{PB}) or six (from $\Delta F1_{CB_OFF}$ to $\Delta F6_{CB_OFF}$ for WBI^{CB}) offset factors.

Focusing on offset factors for WBI^{PB} , $\Delta F4_PB$ is the major offset factor for 35 countries in the very low or low intensity regions, followed by $\Delta F1_PB$ for 33 countries, and $\Delta F3_PB$ for 14 countries. In the moderate-intensity region, six countries have $\Delta F4_PB$ as the major offset factor, followed by $\Delta F5_PB$ for five countries, and $\Delta F2_PB$ for the three countries. In the high or very high intensity regions, ten countries have $\Delta F3_PB$ as the major offset factors, followed by $\Delta F5_PB$ for nine countries, and $\Delta F2_PB$ and $\Delta F4_PB$ for eight countries in a tie.

Figure 2d–f shows the number of countries based on the six promoting factors and six offset factors of the WBI^{CB} . There are 84 countries in the very low or low intensity regions, 23 countries in the moderate intensity region, and 49 countries in the high or very high intensity regions. In the very low or low intensity regions, $\Delta F4_CB$ is the major promoting factor for 47 countries, followed by $\Delta F6_CB$ for 22 countries, and $\Delta F1_CB$ for 11 countries. In the moderate-intensity region, $\Delta F4_CB$ is the major promoting factor for 11 countries, followed by $\Delta F1_CB$ for six countries, and $\Delta F6_CB$ for four countries. In the high or very high intensity regions, $\Delta F4_CB$ is the major promoting factor for 20 countries, followed by $\Delta F1_CB$ for 14 countries, and $\Delta F5_CB$ for seven countries.

Focusing on offset factors for WBI^{CB} in the very low or low intensity regions, $\Delta F5_CB$ is the major promoting factor for 80 countries, followed by $\Delta F4_CB$ for two countries, and $\Delta F1_CB$ and $\Delta F6_CB$ being equal for one country. In the moderate-intensity region, $\Delta F5_CB$ is the major offset factor for 19 countries, followed by $\Delta F2_CB$, $\Delta F3_CB$, $\Delta F4_CB$, and $\Delta F6_CB$ being equal for one country. In the high or very high intensity regions, $\Delta F5_CB$ is the major offset factor for 34 countries, followed by $\Delta F1_CB$ and $\Delta F2_CB$ for five countries in a tie, and $\Delta F4_CB$ and $\Delta F6_CB$ for two countries in a tie.

In summary, based on WBI^{PB} , the renewable freshwater resources factor ($\Delta F1_PB$) becomes the major promoting factor in the very low, low-, and high or very high-intensity regions while $\Delta F1_PB$ and $\Delta F2_PB$ are relatively large promoting factors in the moderate-intensity region. The WBI^{PB} is constrained by renewable freshwater resources and industrial structures rather than food production. The major offset factor for WBI^{PB} is $\Delta F4_PB$ for countries in the very low-to-moderate-intensity regions. The high or very high intensity regions have $\Delta F3_PB$ as the major offset factor for WBI^{PB} . Changing high-calorie food into low-calorie food production is expected to lead to a decrease in the intensities of WBI^{PB} . On the other hand, based on WBI^{CB} , the consumed item preference factor ($\Delta F4_CB$) becomes the major promoting factor for all regions. The major offset factor for WBI^{CB} is the producing area preference ($\Delta F5_CB$) for all regions. Although high-calorie food consumption increases the intensities of WBI^{CB} , food imports from regions with lower water requirements decrease those of WBI^{CB} . The intensities of WBI^{PB} and WBI^{CB} are determined by the balance of the degrees of contribution between the promoting and offset factors.

For example, China belongs to the high or very high intensity regions based on the WBI^{PB} . As shown in Table A1, the major promoting factor is the renewable freshwater resources factor ($\Delta F1_PB_PRO$: 0.44), which is mainly offset by the water footprint intensity factor ($\Delta F5_PB_OFF$: -6.8×10^{-2}). Here, $\Delta F1_PB_PRO$ shows that $\Delta F1_PB$ is a promoting factor (a positive value), whereas $\Delta F5_PB_OFF$ shows that $\Delta F1_PB$ is an offset factor (a negative value). The respective interpretation rules are the same as below. This shows that the promoting effect on renewable water resources is offset by the production of items with relatively low water requirements per calorie content. This country is a high-intensity region of WBI^{PB} according to Figure 1a; this is determined by adding $\Delta F1_PB$ to $\Delta F5_PB$ depending on the balance of degrees of contribution between the three promoting and two offset factors (Table A1). In contrast, this country belongs to the moderate-intensity region based on WBI^{CB} . As shown in Table A2, the major promoting factor is the water footprint intensity factor ($\Delta F6_CB_PRO$: 3.4), which is mainly offset by the producing area preference factor ($\Delta F5_CB_OFF$: -3.4). This shows that the promoting effect on food production with high water requirements per calorie content is offset by food imports from regions with lower water requirements. China is a moderate-intensity region of WBI^{CB} according to Figure 1b; this is determined by adding $\Delta F1_CB$ to $\Delta F6_CB$ depending on the balance of

degrees of contribution between the four promoting and two offset factors (Table A2). In summary, the water balance intensity of WBI^{PB} in China mainly increases because of the renewable freshwater resources factor and is mainly offset by the water footprint intensity factor. On the other hand, the intensities of WBI^{CB} mainly increase because of the producing area preference factor and is offset by the producing area preference factor.

As another example, the United States of America belongs to the moderate-intensity region based on their WBI^{PB} . As shown in Table A1, the major promoting factor is the industrial structure factor ($\Delta F2_PB_PRO$: 8.5×10^{-2}), which is mainly offset by the water footprint intensity ($\Delta F5_PB_OFF$: -3.0×10^{-2}). This occurs because the AWW per capita ($282 \text{ m}^3/\text{capita}$) is less than the IWW per capita ($101 \text{ m}^3/\text{capita}$). This effect is mainly offset by the consumption of items with relatively low water requirements per calorie content. The United States of America is a moderate-intensity region of WBI^{PB} according to Figure 1a, which is determined by adding $\Delta F1_PB$ to $\Delta F5_PB$ depending on the balance of degrees of contribution between the two promoting and three offset factors (Table A1). In contrast, this country belongs to the very low or low intensity regions based on their WBI^{CB} . As shown in Table A2, the major promoting factor is the producing item preference factor ($\Delta F4_CB_PRO$: 0.66), which is mainly offset by the water footprint intensity factor ($\Delta F5_CB_OFF$: -0.87). This shows that the effect of high-calorie content on food consumption is offset by the effect on food imports from regions with lower water requirements. This country is a moderate-intensity region of WBI^{CB} according to Figure 1b, which is determined by adding $\Delta F1_CB$ to $\Delta F6_CB$ depending on the balance of degrees of contribution between the two promoting and four offset factors (Table A2). In summary, the intensities of WBI^{PB} in the United States of America mainly increase owing to the industrial structure factor and are mainly offset by the water footprint intensity factor. On the other hand, the intensities of WBI^{CB} mainly increase because of the consumed item preference factor and are mainly offset by the producing area preference factor.

4. Discussion

In 2010, the $TRWR$ per capita is $8036 \text{ m}^3/\text{capita}$, the AWW per capita is $406 \text{ m}^3/\text{capita}$, and the TWW per capita is $583 \text{ m}^3/\text{capita}$, on a global average. The respective values correspond to $TRWR_0$, AWW_0 , and TWW_0 , those are used in Equations (11) and (16). The ration of AWW_0 to TWW_0 shows that global AWW accounts for approximately 70% of global TWW . Agricultural water demand is prominent and in danger of increasing water balance intensities.

According to Figure 3, rice has a prominent blue water requirement on global average. Its blue water footprint intensity is $5350 \text{ m}^3/\text{ton}$ with $356 \text{ kcal}/100 \text{ g}$ of calorie content, the minimum value in all of the items, considering its irrigation efficiency is 0.1. For cereals, maize has the largest share of global calorie-based production (44% of cereals) and requires $155 \text{ m}^3/\text{ton}$ of blue water. Wheat follows by 33% and $656 \text{ m}^3/\text{ton}$, showing the largest blue water intensity in all cereals, and 6.8% and $152 \text{ m}^3/\text{ton}$ for barley. The respective calorie content are $350 \text{ kcal}/100 \text{ g}$ for maize, $337 \text{ kcal}/100 \text{ g}$ for wheat, and $341 \text{ kcal}/100 \text{ g}$ for barley. For oil crops and oils, olive oil has the largest blue water intensity, requiring $4677 \text{ m}^3/\text{ton}$ of blue water with $921 \text{ kcal}/100 \text{ g}$ of calorie content. However, its share of global calorie-based production is 0.77% for oil crops and oils, which is less than that for palm oil (11% of oil crops and oils), followed by 10% for coconuts, 9.5% for soybean oil, 8.2% for rape and mustard seeds, and 5.7% for cottonseed. The respective blue water intensities are $2 \text{ m}^3/\text{ton}$ with $921 \text{ kcal}/100 \text{ g}$ of calorie content for palm oil, $4 \text{ m}^3/\text{ton}$ with $668 \text{ kcal}/100 \text{ g}$ for coconuts, $263 \text{ m}^3/\text{ton}$ with $921 \text{ kcal}/100 \text{ g}$ for soybean oil, $328 \text{ m}^3/\text{ton}$ with $500 \text{ kcal}/100 \text{ g}$ for rape and mustard seeds, and $802 \text{ m}^3/\text{ton}$ with $506 \text{ kcal}/100 \text{ g}$ for cottonseed. Soybeans have the largest share of global calorie-based production (27% of oil crops and oils) of all the oil crops and oils. Its blue water intensity is $134 \text{ m}^3/\text{ton}$ with $417 \text{ kcal}/100 \text{ g}$ of calorie content. For livestock products, "Meat, Other" (already integrating relatively minor meat items except for bovine, pig, poultry, mutton, and goat meat and edible offal in the FAOSTAT) has the largest blue water intensity ($1223 \text{ m}^3/\text{ton}$) with $119 \text{ kcal}/100 \text{ g}$ of calorie

content. However, its share of global calorie-based production takes the minimum value in all livestock products at only 0.41%. Milk has the largest share of global calorie-based production (28% of livestock products) in all of the livestock products, followed by 18% for pig meat, and 14% for bovine meat. The respective blue water intensities are 165 m³/ton with 66 kcal/100 g of calorie content for milk, 622 m³/ton with 294 kcal/100 g for pig meat, and 1044 m³/ton with 360 kcal/100 g for bovine meat. Poultry meat's share of global calorie-based production is 11%, requiring 601 m³/ton of blue water with 194 kcal/100 g of calorie content. It seems that global blue water requirements mainly increase due to the large production of rice and relatively high water-required items with a large share of global calorie-based production rather than because of items with the largest blue water requirement in each item category. In particular, the blue water requirement for producing oil crops and oils increases due to the production of oil crops rather than oils.

Figure 3. Scatter plot of blue water intensities and calorie conversion factors for six item categories. Note: The target items (78 items) are aggregated in six categories as follows: “Cereals” for 13 items, “Beverages and seasonings” for 13 items, “Fruits and vegetables” for 18 items, “Oil crops and oils” for 22 items, “Livestock products” for 11 items, and “Rice” for one items. The blue water intensity means blue water footprint intensity considering irrigation efficiency on a world average.

The scatter plot in Figure 4a shows a clearly symmetric distribution centered around four on the horizontal axis. There are 98 countries in the very low or low intensity regions, 16 countries in the moderate intensity region, and 42 countries in the high or very high intensity regions. Countries in the very low or low intensity regions have a wide spread ranging from 10³ to 10⁸. Countries in the high or very high regions spread in the range of 10 to 10⁴. Countries with moderate intensity have a spread between 10³ to 10⁴. In the very low or low intensity regions, the largest calorie-based production quantity per capita is 48 GJ/capita in Argentina, followed by 40 GJ/capita in Canada, and 39 GJ/capita in Paraguay. In the moderate-intensity region, the largest calorie-based production quantity per capita is 31 GJ/capita in the United States of America, followed by 22 GJ/capita in Bulgaria and Kazakhstan, and 14 GJ/capita in Slovakia and Thailand. In the high or very high intensity regions, the largest calorie-based production quantity per capita is 40 GJ/capita in Denmark, followed by 26 GJ/capita in France, and 18 GJ/capita in the Czech Republic, Poland and Austria. China has calorie-based production quantity per capita of 8.8 GJ/capita. In summary, calorie-based production quantities per capita tend to be higher in the very low or low intensity regions than in the moderate to very high intensity regions.

Figure 4. (a) Scatter plot of calorie-based production quantities per capita and logarithmic-transformed $TRWR$'s per capita for three water balance intensities of WBI^{PB} worldwide. (b) Scatter plot of calorie-based net trade quantities per capita and logarithmic-transformed $TRWR$'s per capita for three water balance intensities of WBI^{CB} worldwide. Note: $TRWR$'s are short for the renewable total water resources.

Figure 4b shows that countries in the high or very high intensity regions concentrate on net importers. Globally, net importers are dispersed independently of water balance intensities except for several net exporters of the very low or low intensity regions with prominent calorie-based net export quantities per capita. In the high or very high intensity regions, the number of net importers is 43, more than that of net exporters (six countries). In the moderate-intensity region, the number of net importers is 17, more than that of net exporters (six countries). In the very low or low intensity regions, the number of net importers (53 countries) is greater than that of net exporters (31 countries). In total,

113 countries depend on food imports from 43 exporter countries. For example, in the high or very high intensity regions, the largest calorie-based net import quantity per capita is 20 GJ/capita in Djibouti, followed by 12 GJ/capita in the United Arab Emirates and Belgium, and 10 GJ/capita in Israel and The Netherlands. The United States of America has 5.7 GJ/capita of calorie-based net export quantities per capita. The largest calorie-based net export quantity is 7.1 GJ/capita in France, followed by 5.6 GJ/capita in Denmark, and 2.8 GJ/capita in the Republic of Moldova. In the moderate-intensity region, the largest calorie-based net import quantity per capita is 6.3 GJ/capita in the Republic of Korea, followed by 4.8 GJ/capita in Spain, and 4.0 GJ/capita in Saint Lucia and Switzerland. China has 1.1 GJ/capita of calorie-based net import quantities per capita. The largest calorie-based net export quantity per capita is 9.4 GJ/capita in Bulgaria, followed by 4.6 GJ/capita in Kazakhstan, and 1.3 GJ/capita in Slovakia. In the very low or low intensity regions, the largest calorie-based net export quantity per capita is 20 GJ/capita in Paraguay, followed by 19 GJ/capita in Argentina and Australia, and 18 GJ/capita in Uruguay and Canada. The largest calorie-based net import quantity per capita is 8.8 GJ/capita in Portugal, followed by 7.1 GJ/capita in Norway, and 6.6 GJ/capita in Iceland. In summary, most countries are net importers that spread worldwide, whereas food exports are covered by a few net exporters.

Figure 5a,b shows that cereals' share of calorie-based production quantities for each intensity of WBI^{PB} is the largest in all of the items. The respective total calorie-based production quantities are 26,000 PJ ($0.94 \times 10^3 \text{ km}^3$) in the very low or low intensity regions, 13,000 PJ ($0.54 \times 10^3 \text{ km}^3$) in the moderate intensity region, and 27,000 PJ ($3.1 \times 10^3 \text{ km}^3$) in the high or very high intensity regions. In the very low or low intensity regions, the largest share of calorie-based production quantities is 35% ($9.3 \times 10^3 \text{ PJ}$) for cereals, followed by 32% ($8.5 \times 10^3 \text{ PJ}$) for oil crops and oils, 11% ($2.8 \times 10^3 \text{ PJ}$) for rice, and 9.0% ($2.4 \times 10^3 \text{ PJ}$) for livestock products. The respective shares of blue water requirements are 6.5% (61 km^3) for cereals, 1.7% (16 km^3) for oil crops and oils, 69% ($0.65 \times 10^3 \text{ km}^3$) for rice, and 12% ($0.11 \times 10^3 \text{ km}^3$) for livestock products. In the moderate-intensity region, the largest share of calorie-based production quantities is 57% ($7.5 \times 10^3 \text{ PJ}$) for cereals, followed by 21% ($2.7 \times 10^3 \text{ PJ}$) for oil crops and oils, 11% ($1.4 \times 10^3 \text{ PJ}$) for livestock products, and 4.2% ($0.55 \times 10^3 \text{ PJ}$) for rice. The respective shares of blue water requirements are 15% (80 km^3) for cereals, 6.1% (33 km^3) for oil crops and oils, 13% (71 km^3) for livestock products, and 53% ($0.29 \times 10^3 \text{ km}^3$) for rice. In the high or very high intensity regions, the largest share of calorie-based production quantities is 43% ($11 \times 10^3 \text{ PJ}$) for cereals, followed by 18% ($4.8 \times 10^3 \text{ PJ}$) for oil crops and oils, 14% ($3.6 \times 10^3 \text{ PJ}$) for rice, and 12% ($3.2 \times 10^3 \text{ PJ}$) for livestock products. The respective shares of blue water requirements are 22% ($0.67 \times 10^3 \text{ km}^3$) for cereals, 5.3% ($0.16 \times 10^3 \text{ km}^3$) for oil crops and oils, 50% ($1.5 \times 10^3 \text{ km}^3$) for rice, and 11% ($0.33 \times 10^3 \text{ km}^3$) for livestock products. Based on calorie-based production quantities, cereals, rice, livestock products, and oil crops and oils are produced worldwide. However, based on blue water requirements, rice is the most water-intensive item of all because its irrigation efficiency is 0.1, requiring ten times as many water withdrawals as its blue water consumption. In summary, rice and cereals increase global blue water requirements for production because the respective items have the largest share of blue water requirements and calorie-based production quantities in all of the items for all of the regions.

Figure 5. (a) Items' share of calorie-based production quantities and (b) item's share of blue water requirements for production for three water balance intensities of WBI^{PB} . Note: The target items (78 items) are aggregated in the same six categories as Figure 3.

Figure 6a,b depict that the very low and low intensity regions show a net exporter on both bases, whereas the moderate-intensity region shows a net importer. The high or very high intensity regions show a net exporter on a calorie basis in contrast with a net importer region on a blue water requirement basis. In the very low or low intensity regions, the total calorie-based net export quantity is 4.6×10^3 PJ, and the total net export quantity of blue water requirements is 11 km^3 with no net import quantities on both bases. In the moderate-intensity region, the total calorie-based net import quantity is 2.2×10^3 PJ, and the total net import quantity of blue water requirements is 35 km^3 . The total calorie-based net export quantity is 22 PJ with no net export quantities of blue water requirements. In the high or very high intensity regions, the total calorie-based net import quantity is 1.9×10^3 PJ, and the total net import quantity of blue water requirements is 0.38 km^3 . Meanwhile, the total calorie-based net export quantity is 56 PJ, and the total net export quantity of blue water requirements is 21 km^3 . Based on blue water requirements, rice is largely exported to Western Africa (24 km^3 and 16 PJ), followed by Western Asia (23 km^3 and 31 PJ), and Eastern Africa (23 km^3 and 11 PJ). These are offset by rice imports from Southern Asia (43 km^3 and 36 PJ), followed by South-Eastern Asia (11 km^3 and 42 PJ), and North America (6.8 km^3 and 8.1 PJ). Four items (e.g., rice, cereals, livestock products, and oil crops and oils) in particular show net importers on a calorie basis, in contrast with

showing net exporters on a blue water requirement basis. This contrast could be caused by the stacked difference of blue water requirements because the blue water intensity for each item is different between producing countries. The calorie conversion factor for each item is constant and not separately set among producing countries. In summary, oil crops and oils have the largest share of calorie-based net trade worldwide. However, blue water requirements for oil crops and oils are less than those for rice and as much as those of cereals. Thus, rice trade increases global blue water requirements.

(a)

(b)

Figure 6. (a) Items' share of calorie-based net trade quantities and (b) items' share of net trade quantities of blue water requirements for three water balance intensities of WBI^{CB} . Note: The target items (78 items) are aggregated in the same six categories as Figure 3.

5. Conclusions

This study aims to evaluate the intensities of water supply-demand balances (water balance intensities) and elucidate the promoting factors of water balance intensities (promoting factors) or offset factors of water balance intensities (offset factors) for each country, focusing on food supply-demand balances and considering food trade balances on a global scale. A complete decomposition analysis is applied to both the WBI^{PB} and the WBI^{CB} to analyze the promoting and offset factors of both WBI 's. The WBI^{PB} is decomposed into five factors as follows: a renewable freshwater resources factor, an industrial structure factor, a production scale factor, a produced item preference factor, and a water footprint intensity factor. The WBI^{CB} is decomposed into six factors as follows: a renewable freshwater resources factor, an industrial structure factor, a consumption scale factor, a consumed item

preference factor, a producing area preference factor, and a water footprint intensity factor. The elucidation of the promoting and offset factors of both WBIs is expected to provide essential knowledge for decreasing water balance intensities regarding food production and consumption based on water resource management. In this study, the following three results are revealed:

- (1) The water balance intensity for each country is evaluated using five intensity categories: very low, low, moderate, high, and very high. 58 countries from moderate to very high intensity regions on a WBI^{PB} basis tend to be distributed around mid-latitude regions including arid regions, large population regions, and industrialized countries. In contrast, 72 countries from moderate to very high intensity regions on a WBI^{CB} basis are spread worldwide. Comparing intensities between WBI^{PB} and WBI^{CB} , the former is higher for 17 countries, whereas the latter is higher for 36 countries. In addition, 103 countries are approximately the same, including 40 countries from moderate to very high regions.
- (2) Each country is classified into one of three regions: the very low or low intensity region, the moderate intensity region, and the high or very high intensity region. Based on WBI^{PB} , the renewable freshwater resources factor is the major promoting factor in the very low or low and the high or very high intensity regions, while the renewable freshwater resources and industrial structure factors are relatively large promoting factors in the moderate-intensity region. The major offset factor of WBI^{PB} is the consumed item preference factor for countries in the very low to moderate-intensity regions. The high or very high intensity regions have the production scale factor as the major offset factor of the WBI^{PB} . Based on WBI^{CB} , the consumed item preference factor is the major promoting factor for countries from the very low to moderate regions, and the renewable freshwater resources factor is the major promoting factor for countries in the high or very high intensity regions. In contrast, the major offset factor of WBI^{CB} is the producing area preference for all regions. The water balance intensities of WBI^{PB} and WBI^{CB} are determined to balance the degrees of contribution between the promoting and offset factors.
- (3) This study reviews two countries (China and the United States of America) in more detail. In China, the renewable freshwater resources factor is mainly offset by the water footprint intensity factor based on WBI^{PB} . In contrast, the water footprint intensity factor is mainly offset by the producing area preference factor based on WBI^{CB} . In the United States of America, the water balance intensity of WBI^{PB} mainly increases because of the industrial structure factor, which is offset by the water footprint intensity factor. In contrast, the water balance intensity of WBI^{CB} increases because of the consumed item preference factor, which is offset by the producing area preference factor.

A discussion focusing on food production and trade is provided. Calorie-based production quantities tend to be higher for countries in the very low or low intensity regions than for those in the moderate to very high regions. Most countries are net importers that spread worldwide, whereas food exports are covered by a few net exporters. Rice and cereals increase global blue water requirements for production because the respective items have the largest share of blue water requirements and calorie-based production quantities in all of the items for all of the regions. Oil crops and oils have the largest share of calorie-based net trade worldwide. However, blue water requirements for oil crops and oils are less than those for rice and as much as those for cereal. Thus, rice trade increases global blue water requirements. It is effective to improve irrigation efficiency for rice and cereals because rice has the largest blue water footprint intensity considering irrigation efficiency in all of the items, whereas cereals show the largest share of calorie-based production quantities in all of the items for all of the regions.

Several problems need to be addressed in future studies. This study in particular analyzes water balance intensities, focusing on the elucidation of a global distribution tendency of degrees of promoting and offset factors for each country. Therefore, this

study could not refer to the relationship between countries in detail. For this reason, more detailed analyses at the regional or country level are necessary. In addition, the standard value of this study differs for each country to apply the complete decomposition analysis to spatial data. The standard value for each factor, the renewable freshwater resources, industrial structure, production (for WBI^{PB}), and consumption scale (for WBI^{CB}) factors are set by using world average values per capita while the water footprint intensity factor is set by using the world average values. In contrast, the produced and consumed item preferences (for WBI^{PB} and WBI^{CB} , respectively) and producing area preference (for only WBI^{CB}) factors are set by using distinct values for each country. Additional analyses from various points of view are necessary. Using time series data as degrees of contribution factors can easily change depending on the method of taking standard values and selecting parameters and indices.

This study quantifies water balance intensities based on macroeconomic statistics, such as FAOSTAT and AQUASTAT when calculating food supply-demand factors (food production, consumption, and net trade) and water-related factors (total renewable water resources, agricultural withdrawal rate, and water footprint intensity) to evaluate the effect of these factors on water balance intensities. Therefore, this study could not consider accelerating changes in water footprint, such as various irrigation technology, cultivation methods, and agricultural activities. In addition, green water is excluded from the evaluation target of this study. However, green water could become an indirect effect on water balance intensities because decreasing the availability of green water causes additional blue water use. Additional analysis is necessary to develop this study for the future. For example, creating a new decomposition formula for water requirements incorporating the ratio of virtual water to real water and that for food production incorporating crop yield could adopt appropriate policies to conserve water resources and increase crop productivity, respectively. In addition, analyzing the value of virtual water enables to evaluate the effect of trade dependence between countries on water balance intensities, and therefore, could add economic viewpoint to this study.

It should be noted that this study is based on the FAOSTAT, and therefore the quality of all results of this study highly rely on the data limitation and drawbacks of this statistics. This study could not consider the input-output balances between raw materials and processed goods because the FAOSTAT does not refer to the relationship between two. In addition, this study could not cover unreported data of the FAOSTAT. This statistics' quality depends on the quality of received data, supplied by national statistical authorities or by other international organizations [42]. In future work, the analysis combined with input-output tables is desirable.

Author Contributions: Conceptualization, Y.Y., N.Y., K.A. and S.H.; methodology, Y.Y., N.Y., K.A. and S.H.; software, Y.Y.; validation, Y.Y., N.Y., K.A. and S.H.; formal analysis, Y.Y.; investigation, Y.Y.; resources, N.Y.; data curation, Y.Y., N.Y., K.A. and S.H.; writing—original draft preparation, Y.Y.; writing—review & editing, Y.Y., N.Y., K.A. and S.H.; visualization, Y.Y., N.Y., K.A. and S.H.; supervision, K.A.; project administration, K.A.; funding acquisition, K.A. and N.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This research was partially supported by the Program for the Strategic Research Foundation at Private Universities, Ministry of Education, Culture, Sports, Science and Technology (MEXT) Japan (S1411032).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Decomposition results of WBI^{PB} (unit: %).

Country	Area	Intensities	SS_PB	$\Delta F1_PB$	$\Delta F2_PB$	$\Delta F3_PB$	$\Delta F4_PB$	$\Delta F5_PB$	ΔFt_PB	WBI_PB	WBI_PB_0
MWI	EAFR	Very Low	44	3.0	-3.6×10^{-3}	-0.34	-2.3	-0.42	-2.8×10^{-2}	7.8×10^{-2}	0.11
MUS	EAFR	Very Low	31	0.38	2.9×10^{-3}	2.2×10^{-2}	-0.44	-1.8×10^{-2}	-5.3×10^{-2}	3.8×10^{-2}	9.1×10^{-2}
MOZ	EAFR	Very Low	48	-1.8×10^{-3}	-5.3×10^{-4}	-3.7×10^{-2}	-4.5×10^{-2}	-1.0×10^{-2}	-9.4×10^{-2}	1.1×10^{-2}	0.11
ZWE	EAFR	Very Low	58	1.4	-2.8×10^{-3}	-0.45	-0.92	-0.11	-3.1×10^{-2}	7.8×10^{-2}	0.11
RWA	EAFR	Very Low	39	4.0	4.2×10^{-3}	-1.1	-2.7	-0.14	-3.0×10^{-2}	7.4×10^{-2}	0.10
UGA	EAFR	Very Low	50	-11	-4.9	3.7	11	0.64	-5.0×10^{-2}	5.5×10^{-2}	0.11
ETH	EAFR	Very Low	55	1.0	-4.8×10^{-3}	-0.12	-0.81	-0.15	-5.8×10^{-2}	5.1×10^{-2}	0.11
ZMB	EAFR	Very Low	42	6.5×10^{-3}	-1.1×10^{-3}	-2.5×10^{-2}	-6.5×10^{-2}	4.0×10^{-3}	-8.1×10^{-2}	2.5×10^{-2}	0.11
AGO	MAFR	Very Low	43	6.3×10^{-2}	0.78	-0.36	-0.49	-4.3×10^{-2}	-5.8×10^{-2}	4.7×10^{-2}	0.11
CMR	MAFR	Very Low	52	-1.7×10^{-2}	1.1×10^{-4}	-6.7×10^{-3}	-6.2×10^{-2}	-1.3×10^{-2}	-9.9×10^{-2}	7.5×10^{-3}	0.11
TCD	MAFR	Very Low	34	0.17	-1.4×10^{-3}	-0.11	-0.12	-2.3×10^{-2}	-8.3×10^{-2}	2.0×10^{-2}	0.10
COG	MAFR	Very Low	39	-4.5×10^{-2}	0.12	-7.1×10^{-2}	-9.0×10^{-2}	-6.9×10^{-3}	-8.9×10^{-2}	1.9×10^{-3}	9.1×10^{-2}
GAB	MAFR	Very Low	29	-4.0×10^{-2}	1.8×10^{-2}	-2.3×10^{-2}	-3.9×10^{-2}	-4.4×10^{-3}	-8.8×10^{-2}	1.2×10^{-3}	9.0×10^{-2}
NAM	SAFR	Very Low	31	-9.8×10^{-3}	9.5×10^{-6}	-1.4×10^{-2}	-3.9×10^{-3}	-1.8×10^{-3}	-2.9×10^{-2}	4.5×10^{-3}	3.4×10^{-2}
BEN	WAFR	Very Low	48	1.7	0.63	-1.0	-1.3	-7.3×10^{-2}	-3.8×10^{-2}	5.7×10^{-2}	9.5×10^{-2}
GHA	WAFR	Very Low	44	0.95	6.7×10^{-3}	-0.36	-0.60	-1.9×10^{-2}	-3.2×10^{-2}	5.7×10^{-2}	9.0×10^{-2}
GIN	WAFR	Very Low	38	-4.0×10^{-2}	1.5×10^{-2}	-2.0×10^{-2}	1.2×10^{-2}	-3.7×10^{-2}	-7.1×10^{-2}	2.0×10^{-2}	9.1×10^{-2}
LBR	WAFR	Very Low	31	-5.6×10^{-2}	-8.2×10^{-3}	3.9×10^{-2}	-8.5×10^{-3}	-2.2×10^{-2}	-5.5×10^{-2}	3.2×10^{-2}	8.7×10^{-2}
NGA	WAFR	Very Low	49	0.34	-0.29	0.13	-0.26	4.9×10^{-2}	-2.0×10^{-2}	8.5×10^{-2}	0.11
GNB	WAFR	Very Low	33	-4.7×10^{-2}	-5.5×10^{-3}	-9.2×10^{-3}	1.1×10^{-2}	-7.3×10^{-5}	-5.1×10^{-2}	3.7×10^{-2}	8.8×10^{-2}
SEN	WAFR	Very Low	38	4.7×10^{-2}	-1.4×10^{-2}	2.4×10^{-2}	-7.9×10^{-3}	-5.8×10^{-2}	-9.2×10^{-3}	8.4×10^{-2}	9.3×10^{-2}
SLE	WAFR	Very Low	38	-4.6×10^{-2}	5.4×10^{-2}	-1.8×10^{-2}	-2.7×10^{-2}	-7.5×10^{-3}	-4.4×10^{-2}	4.6×10^{-2}	9.0×10^{-2}
TGO	WAFR	Very Low	44	48	18	-37	-24	-6.0	-3.5×10^{-2}	5.6×10^{-2}	9.0×10^{-2}
CAN	NAME	Very Low	43	-2.6×10^{-2}	-17	-0.99	-0.37	19	-1.8×10^{-2}	2.2×10^{-2}	4.0×10^{-2}
BLZ	CAME	Very Low	35	-5.6×10^{-2}	3.1×10^{-4}	2.1×10^{-3}	-1.6×10^{-2}	-1.9×10^{-2}	-8.8×10^{-2}	3.5×10^{-3}	9.2×10^{-2}
CRI	CAME	Very Low	45	-5.2×10^{-2}	8.6×10^{-3}	8.2×10^{-5}	-1.6×10^{-2}	-3.7×10^{-3}	-6.3×10^{-2}	3.0×10^{-2}	9.3×10^{-2}
SLV	CAME	Very Low	43	7.8×10^{-2}	3.0×10^{-3}	-6.4×10^{-3}	-0.17	3.0×10^{-2}	-6.6×10^{-2}	2.9×10^{-2}	9.4×10^{-2}
GTM	CAME	Very Low	54	-1.4×10^{-3}	2.5×10^{-2}	-6.1×10^{-3}	-8.7×10^{-2}	-1.9×10^{-2}	-8.9×10^{-2}	1.9×10^{-2}	0.11
HND	CAME	Very Low	53	-9.6×10^{-3}	-2.8×10^{-4}	-1.4×10^{-2}	-6.2×10^{-2}	-8.7×10^{-3}	-9.4×10^{-2}	1.2×10^{-2}	0.11
NIC	CAME	Very Low	43	-4.9×10^{-2}	-1.2×10^{-4}	-1.3×10^{-2}	-1.5×10^{-3}	-1.8×10^{-2}	-8.1×10^{-2}	1.1×10^{-2}	9.3×10^{-2}
PAN	CAME	Very Low	37	-4.5×10^{-2}	1.6×10^{-2}	-2.4×10^{-2}	3.7×10^{-3}	-3.4×10^{-2}	-8.2×10^{-2}	9.1×10^{-3}	9.1×10^{-2}

Table A1. Cont.

Country	Area	Intensities	SS_PB	$\Delta F1_PB$	$\Delta F2_PB$	$\Delta F3_PB$	$\Delta F4_PB$	$\Delta F5_PB$	ΔFt_PB	WBI_PB	WBI_PB_0
JAM	CARI	Very Low	39	0.19	4.0×10^{-2}	-4.6×10^{-2}	-0.22	-1.6×10^{-2}	-5.4×10^{-2}	3.7×10^{-2}	9.1×10^{-2}
LCA	CARI	Very Low	28	0.19	-9.5×10^{-5}	-5.6×10^{-2}	-0.12	-9.6×10^{-3}	7.2×10^{-3}	2.3×10^{-2}	1.6×10^{-2}
ARG	SAME	Very Low	60	-5.2×10^{-2}	-6.9×10^{-4}	3.1×10^{-2}	-4.7×10^{-2}	-1.0×10^{-2}	-8.0×10^{-2}	3.1×10^{-2}	0.11
BOL	SAME	Very Low	56	-6.0×10^{-2}	1.7×10^{-3}	1.4×10^{-3}	-2.3×10^{-2}	-2.5×10^{-2}	-0.10	4.2×10^{-3}	0.11
BRA	SAME	Very Low	65	-7.4×10^{-2}	3.7×10^{-3}	1.2×10^{-2}	-2.6×10^{-2}	-1.2×10^{-2}	-9.6×10^{-2}	1.4×10^{-2}	0.11
CHL	SAME	Very Low	48	-6.8×10^{-2}	5.4×10^{-4}	-5.2×10^{-3}	-2.8×10^{-2}	5.7×10^{-3}	-9.5×10^{-2}	1.2×10^{-2}	0.11
COL	SAME	Very Low	58	-6.9×10^{-2}	5.4×10^{-3}	-1.9×10^{-2}	-1.1×10^{-2}	-8.0×10^{-3}	-0.10	8.8×10^{-3}	0.11
ECU	SAME	Very Low	59	-6.9×10^{-2}	-3.9×10^{-3}	-4.3×10^{-3}	-1.0×10^{-3}	1.8×10^{-3}	-7.6×10^{-2}	3.1×10^{-2}	0.11
GUY	SAME	Very Low	36	-8.0×10^{-2}	-2.4×10^{-3}	2.0×10^{-3}	2.8×10^{-3}	-2.0×10^{-3}	-7.9×10^{-2}	1.0×10^{-2}	9.0×10^{-2}
PRY	SAME	Very Low	51	-7.7×10^{-2}	-1.2×10^{-4}	1.0×10^{-2}	-1.9×10^{-2}	-1.3×10^{-2}	-0.10	8.1×10^{-3}	0.11
PER	SAME	Very Low	62	-8.4×10^{-2}	-3.5×10^{-3}	-6.2×10^{-3}	-7.0×10^{-4}	-9.6×10^{-4}	-9.6×10^{-2}	1.4×10^{-2}	0.11
SUR	SAME	Very Low	36	-7.9×10^{-2}	2.4×10^{-5}	-1.7×10^{-3}	6.2×10^{-3}	-1.9×10^{-3}	-7.6×10^{-2}	1.4×10^{-2}	9.0×10^{-2}
URY	SAME	Very Low	49	-7.7×10^{-2}	-3.0×10^{-3}	3.7×10^{-2}	-1.7×10^{-3}	8.6×10^{-4}	-4.4×10^{-2}	6.3×10^{-2}	0.11
VEN	SAME	Very Low	54	-6.2×10^{-2}	9.6×10^{-4}	-2.8×10^{-2}	-6.3×10^{-3}	-5.0×10^{-3}	-0.10	6.3×10^{-3}	0.11
MNG	EASI	Very Low	23	-7.4×10^{-3}	2.1×10^{-2}	-1.6×10^{-2}	2.3×10^{-2}	-6.0×10^{-3}	1.5×10^{-2}	4.4×10^{-2}	3.0×10^{-2}
NPL	SASI	Very Low	47	2.6×10^{-3}	-2.6×10^{-2}	-2.8×10^{-2}	2.5×10^{-2}	1.1×10^{-2}	-1.5×10^{-2}	9.2×10^{-2}	0.11
MMR	SEASI	Very Low	48	-5.7×10^{-2}	-7.7×10^{-3}	2.1×10^{-3}	6.4×10^{-3}	-1.8×10^{-2}	-7.4×10^{-2}	3.2×10^{-2}	0.11
IDN	SEASI	Very Low	49	-2.2×10^{-3}	-1.1×10^{-2}	4.3×10^{-3}	2.9×10^{-2}	-2.9×10^{-2}	-8.7×10^{-3}	8.6×10^{-2}	9.4×10^{-2}
KHM	SEASI	Very Low	37	-5.8×10^{-2}	-6.4×10^{-3}	-2.5×10^{-3}	2.3×10^{-2}	-1.2×10^{-2}	-5.5×10^{-2}	3.7×10^{-2}	9.2×10^{-2}
LAO	SEASI	Very Low	36	-6.8×10^{-2}	-4.2×10^{-3}	-4.1×10^{-4}	5.5×10^{-3}	-8.2×10^{-3}	-7.5×10^{-2}	1.7×10^{-2}	9.2×10^{-2}
TLS	SEASI	Very Low	28	6.1×10^{-3}	-1.3×10^{-2}	-4.3×10^{-2}	2.6×10^{-2}	-2.1×10^{-2}	-4.5×10^{-2}	4.2×10^{-2}	8.7×10^{-2}
VNM	SEASI	Very Low	45	-1.3×10^{-2}	-1.9×10^{-2}	-5.5×10^{-3}	6.0×10^{-2}	-2.8×10^{-2}	-4.9×10^{-3}	8.9×10^{-2}	9.4×10^{-2}
GEO	WASI	Very Low	40	-8.6×10^{-3}	4.4×10^{-3}	-1.8×10^{-2}	5.4×10^{-3}	-6.5×10^{-3}	-2.3×10^{-2}	1.4×10^{-2}	3.7×10^{-2}
IRQ	WASI	Very Low	46	0.32	-3.8×10^{-3}	-0.19	-0.20	5.5×10^{-2}	-1.3×10^{-2}	9.4×10^{-2}	0.11
BLR	EEUR	Very Low	40	1.4×10^{-2}	0.10	2.6×10^{-2}	-3.5×10^{-3}	-0.10	3.3×10^{-2}	7.3×10^{-2}	4.0×10^{-2}
ROU	EEUR	Very Low	47	-8.6×10^{-3}	1.1	8.7×10^{-2}	-0.85	-0.32	-7.9×10^{-3}	0.10	0.11
RUS	EEUR	Very Low	48	-5.4×10^{-2}	0.22	9.7×10^{-3}	-0.32	7.5×10^{-2}	-6.5×10^{-2}	4.3×10^{-2}	0.11
ISL	NEUR	Very Low	17	-1.2×10^{-2}	2.3×10^{-4}	-1.7×10^{-3}	-3.5×10^{-4}	-1.2×10^{-3}	-1.5×10^{-2}	4.0×10^{-4}	1.6×10^{-2}
LVA	NEUR	Very Low	36	-7.5×10^{-3}	-0.18	-3.7×10^{-2}	0.35	-0.14	-1.7×10^{-2}	1.6×10^{-2}	3.2×10^{-2}
LTU	NEUR	Very Low	38	1.2×10^{-3}	0.42	-8.6×10^{-3}	-0.28	-8.8×10^{-2}	4.1×10^{-2}	7.9×10^{-2}	3.8×10^{-2}
NOR	NEUR	Very Low	29	-1.7×10^{-2}	7.1×10^{-3}	-1.9×10^{-3}	-2.1×10^{-3}	-1.4×10^{-2}	-2.8×10^{-2}	2.1×10^{-3}	3.0×10^{-2}
SWE	NEUR	Very Low	35	-9.8×10^{-3}	0.14	-2.3×10^{-2}	1.2	-1.3	4.2×10^{-2}	7.6×10^{-2}	3.4×10^{-2}
AUS	AUNZ	Very Low	61	-5.6×10^{-2}	7.6×10^{-3}	3.3×10^{-2}	-4.4×10^{-2}	-1.6×10^{-4}	-6.0×10^{-2}	5.1×10^{-2}	0.11

Table A1. Cont.

Country	Area	Intensities	SS_PB	$\Delta F1_PB$	$\Delta F2_PB$	$\Delta F3_PB$	$\Delta F4_PB$	$\Delta F5_PB$	ΔFt_PB	WBI_PB	WBI_PB_0
NZL	AUNZ	Very Low	38	-2.3×10^{-2}	5.9×10^{-4}	3.9×10^{-3}	3.7×10^{-3}	-8.1×10^{-3}	-2.3×10^{-2}	1.2×10^{-2}	3.5×10^{-2}
FJI	MELA	Very Low	32	-3.5×10^{-2}	4.4×10^{-3}	1.1×10^{-3}	-5.0×10^{-2}	-6.4×10^{-3}	-8.7×10^{-2}	3.5×10^{-3}	9.0×10^{-2}
KEN	EAFR	Low	59	25	-4.0×10^{-2}	-6.8	-18	0.56	5.1×10^{-2}	0.16	0.11
MDG	EAFR	Low	53	-3.7×10^{-2}	-1.3×10^{-2}	-2.5×10^{-2}	6.4×10^{-2}	2.5×10^{-2}	1.4×10^{-2}	0.12	0.11
TZA	EAFR	Low	62	-0.20	-1.1×10^{-2}	0.18	0.19	-0.14	1.6×10^{-2}	0.12	0.11
BWA	SAFR	Low	29	1.5×10^{-2}	2.0×10^{-2}	-2.2×10^{-2}	3.1×10^{-2}	4.8×10^{-2}	9.3×10^{-2}	0.11	2.1×10^{-2}
LSO	SAFR	Low	22	-18	-0.12	19	-0.50	-0.19	9.2×10^{-2}	0.12	3.1×10^{-2}
SWZ	SAFR	Low	35	0.15	-7.0×10^{-3}	1.0×10^{-3}	-8.7×10^{-2}	-7.9×10^{-3}	5.1×10^{-2}	0.16	0.10
CPV	WAFR	Low	24	-11	-2.1×10^{-3}	9.9	0.73	0.70	8.4×10^{-2}	0.10	2.0×10^{-2}
GMB	WAFR	Low	25	0.22	0.13	-0.34	-3.3×10^{-2}	4.1×10^{-2}	1.9×10^{-2}	0.11	8.7×10^{-2}
CIV	WAFR	Low	48	0.21	0.14	-0.21	-8.0×10^{-2}	-4.0×10^{-2}	2.4×10^{-2}	0.12	9.4×10^{-2}
MRT	WAFR	Low	26	9.6×10^{-2}	-1.4×10^{-2}	-2.3×10^{-2}	-1.9×10^{-2}	2.8×10^{-3}	4.3×10^{-2}	0.14	9.6×10^{-2}
NER	WAFR	Low	38	0.81	5.8×10^{-3}	-6.2×10^{-2}	-0.77	1.5×10^{-2}	-6.6×10^{-4}	0.10	0.10
MEX	CAME	Low	70	0.18	-3.5×10^{-3}	-2.3×10^{-2}	-0.17	2.2×10^{-2}	5.6×10^{-3}	0.12	0.11
CUB	CARI	Low	40	0.27	8.5×10^{-3}	-0.12	2.0×10^{-2}	-0.16	1.7×10^{-2}	0.11	9.1×10^{-2}
GRD	CARI	Low	36	-5.2×10^{-2}	-1.7	1.3	0.65	-0.13	9.9×10^{-2}	0.12	2.2×10^{-2}
HTI	CARI	Low	38	0.84	-5.8×10^{-3}	-0.45	3.8×10^{-3}	-0.34	3.9×10^{-2}	0.13	9.2×10^{-2}
KGZ	CASI	Low	51	0.11	-1.3×10^{-2}	-1.2×10^{-2}	-9.8×10^{-2}	5.4×10^{-2}	3.8×10^{-2}	0.15	0.11
JPN	EASI	Low	55	-0.13	4.5×10^{-3}	0.25	-0.18	4.9×10^{-2}	-3.5×10^{-3}	0.10	0.11
PRK	EASI	Low	34	0.20	-6.6×10^{-3}	-8.8×10^{-2}	-1.2×10^{-2}	-1.6×10^{-2}	8.0×10^{-2}	0.18	0.10
BGD	SASI	Low	48	-1.9×10^{-4}	-1.6×10^{-2}	-3.7×10^{-2}	6.4×10^{-2}	-1.5×10^{-2}	-4.8×10^{-3}	0.10	0.11
MYS	SEASI	Low	45	-4.9×10^{-2}	0.11	3.5×10^{-2}	-6.7×10^{-2}	4.8×10^{-3}	3.0×10^{-2}	0.12	9.2×10^{-2}
PHL	SEASI	Low	51	5.4×10^{-2}	-1.1×10^{-2}	-3.3×10^{-4}	6.1×10^{-3}	-4.2×10^{-2}	6.5×10^{-3}	0.10	9.5×10^{-2}
AZE	WASI	Low	48	0.12	-2.9×10^{-3}	-9.7×10^{-3}	-0.17	9.3×10^{-2}	3.4×10^{-2}	0.14	0.11
HUN	EEUR	Low	50	-5.6×10^{-3}	3.9	-1.7×10^{-2}	-2.8	-1.1	1.7×10^{-2}	0.12	0.11
UKR	EEUR	Low	48	0.50	0.44	-1.1×10^{-2}	-0.93	5.7×10^{-2}	6.3×10^{-2}	0.17	0.11
FIN	NEUR	Low	33	-1.1×10^{-2}	3.7	-2.3×10^{-2}	0.73	-4.3	9.8×10^{-2}	0.13	3.4×10^{-2}
IRL	NEUR	Low	32	-4.0×10^{-3}	0.30	2.3×10^{-2}	-0.11	-0.12	9.1×10^{-2}	0.12	3.0×10^{-2}
GBR	NEUR	Low	37	-0.14	-0.16	5.3×10^{-3}	3.9×10^{-2}	0.39	0.13	0.16	3.5×10^{-2}
ALB	SEUR	Low	44	-5.6×10^{-3}	4.3×10^{-2}	-1.2×10^{-2}	2.2×10^{-2}	1.6×10^{-2}	6.3×10^{-2}	0.11	4.2×10^{-2}
GRC	SEUR	Low	60	3.1×10^{-2}	-1.2×10^{-2}	9.2×10^{-3}	-2.2×10^{-2}	8.6×10^{-3}	1.4×10^{-2}	0.12	0.11
HRV	SEUR	Low	47	-1.5×10^{-2}	5.1	-6.9×10^{-2}	-6.2×10^{-3}	-4.9	0.13	0.17	4.3×10^{-2}
PRT	SEUR	Low	54	1.1×10^{-2}	-6.5×10^{-3}	-2.0×10^{-2}	-2.6×10^{-2}	3.9×10^{-2}	-2.2×10^{-3}	0.11	0.11

Table A1. Cont.

Country	Area	Intensities	SS_PB	$\Delta F1_PB$	$\Delta F2_PB$	$\Delta F3_PB$	$\Delta F4_PB$	$\Delta F5_PB$	ΔFt_PB	WBI_PB	WBI_PB_0
CHE	WEUR	Low	44	3.6×10^{-2}	0.80	2.2×10^{-2}	-9.6×10^{-2}	-0.63	0.14	0.18	4.1×10^{-2}
CAF	MAFR	Moderate	38	-2.9×10^{-2}	2.2×10^2	-34	-46	-1.4×10^2	0.15	0.24	9.1×10^{-2}
ZAF	SAFR	Moderate	60	2.2	3.1×10^{-2}	4.6×10^{-4}	-2.2	0.16	0.18	0.29	0.11
MLI	WAFR	Moderate	41	7.3×10^{-4}	-2.3×10^{-2}	-1.1×10^{-2}	2.4×10^{-2}	0.13	0.12	0.23	0.11
BFA	WAFR	Moderate	38	-6.0	-0.12	0.85	6.2	-0.72	0.15	0.24	9.4×10^{-2}
USA	NAME	Moderate	62	-1.7×10^{-2}	8.5×10^{-2}	6.8×10^{-2}	-1.4×10^{-2}	-3.0×10^{-2}	9.1×10^{-2}	0.20	0.11
DMA	CARI	Moderate	29	-0.13	4.1	-6.0×10^{-2}	6.5×10^{-2}	-3.8	0.23	0.25	2.1×10^{-2}
KAZ	CASI	Moderate	51	3.2×10^{-2}	6.4×10^{-3}	8.7×10^{-2}	-6.4×10^{-2}	0.22	0.28	0.39	0.11
KOR	EASI	Moderate	50	0.59	6.0×10^{-2}	1.5×10^{-2}	-0.44	-4.1×10^{-2}	0.19	0.29	0.10
AFG	SASI	Moderate	36	0.12	-2.2×10^{-2}	2.4×10^{-2}	6.8×10^{-2}	3.3×10^{-2}	0.22	0.33	0.10
THA	SEASI	Moderate	57	2.8×10^{-2}	-1.9×10^{-2}	1.4×10^{-2}	0.25	1.8×10^{-2}	0.29	0.40	0.11
ARM	WASI	Moderate	33	0.22	2.6×10^{-3}	-7.1×10^{-2}	3.5×10^{-2}	9.6×10^{-3}	0.20	0.24	3.8×10^{-2}
TUR	WASI	Moderate	64	0.62	-3.3×10^{-3}	3.1×10^{-2}	-0.65	0.13	0.12	0.23	0.11
BGR	EEUR	Moderate	50	-0.21	10	0.79	-11	-5.4×10^{-3}	0.24	0.34	0.11
SVK	EEUR	Moderate	46	-2.3×10^{-3}	1.9	-2.3×10^{-2}	0.41	-2.1	0.18	0.22	4.2×10^{-2}
ITA	SEUR	Moderate	59	0.61	7.4×10^{-2}	-1.1×10^{-2}	-0.50	-1.8×10^{-2}	0.15	0.26	0.11
MKD	SEUR	Moderate	47	1.1	1.5	-0.15	-0.95	-1.3	0.18	0.28	0.11
DJI	EAFR	High	16	2.9	-0.37	-1.2	-0.60	-0.29	0.48	0.49	1.8×10^{-2}
MAR	NAFR	High	60	4.1	-8.5×10^{-3}	-0.30	-3.6	0.30	0.45	0.56	0.11
SDN	NAFR	High	42	3.6	-8.9×10^{-3}	-0.71	-2.4	0.13	0.59	0.69	0.10
ATG	CARI	High	21	4.2	-2.1×10^{-2}	-3.5	-0.38	4.3×10^{-2}	0.39	0.41	2.0×10^{-2}
BRB	CARI	High	26	-0.16	-8.0×10^{-3}	0.32	-0.54	0.92	0.52	0.54	2.3×10^{-2}
DOM	CARI	High	44	0.32	-1.0×10^{-2}	-7.3×10^{-2}	6.1×10^{-2}	8.2×10^{-2}	0.38	0.47	9.2×10^{-2}
TTO	CARI	High	34	-1.3	13	-5.6	-5.2	-4.1×10^{-2}	0.39	0.48	8.6×10^{-2}
TJK	CASI	High	44	-0.40	-1.4×10^{-2}	0.25	0.63	-5.0×10^{-2}	0.42	0.52	0.10
TKM	CASI	High	28	9.1×10^{-2}	-2.6×10^{-2}	4.7×10^{-3}	3.5×10^{-2}	0.29	0.39	0.50	0.10
UZB	CASI	High	50	0.20	-1.6×10^{-2}	3.5×10^{-3}	0.21	0.10	0.50	0.61	0.10
CHN	EASI	High	70	0.44	1.1×10^{-2}	-9.2×10^{-3}	4.5×10^{-3}	-6.8×10^{-2}	0.38	0.49	0.11
LKA	SASI	High	46	0.41	-1.5×10^{-2}	-8.3×10^{-2}	0.11	0.10	0.52	0.62	9.4×10^{-2}
IND	SASI	High	63	0.49	-2.3×10^{-2}	-5.9×10^{-2}	0.13	0.11	0.65	0.76	0.11
CYP	WASI	High	36	1.4	3.0×10^{-3}	-0.27	-3.8×10^{-2}	-0.46	0.67	0.70	3.3×10^{-2}
LBN	WASI	High	45	1.4	4.1×10^{-2}	-0.49	-1.5×10^{-2}	-0.26	0.72	0.76	3.8×10^{-2}
POL	EEUR	High	45	9.3×10^{-2}	-0.90	-8.0×10^{-2}	-0.14	1.5	0.51	0.55	4.1×10^{-2}
ESP	SEUR	High	61	0.38	2.6×10^{-3}	4.1×10^{-2}	0.16	-4.6×10^{-2}	0.54	0.65	0.11

Table A1. Cont.

Country	Area	Intensities	SS_PB	$\Delta F1_PB$	$\Delta F2_PB$	$\Delta F3_PB$	$\Delta F4_PB$	$\Delta F5_PB$	ΔFt_PB	WBI_PB	WBI_PB_0
AUT	WEUR	High	42	-2.4×10^{-3}	1.9	-0.12	2.5	-3.8	0.47	0.52	4.1×10^{-2}
FRA	WEUR	High	53	-0.51	1.1	0.11	-6.7×10^{-2}	-0.21	0.47	0.58	0.11
DZA	NAFR	Very High	47	-61	-7.2	16	52	1.3	1.1	1.2	0.11
EGY	NAFR	Very High	56	1.9	-2.0×10^{-2}	-0.15	-0.10	0.48	2.1	2.2	0.11
TUN	NAFR	Very High	48	1.1	-2.8×10^{-3}	8.6×10^{-3}	-0.31	0.43	1.2	1.3	3.6×10^{-2}
KNA	CARI	Very High	22	-2.3	-5.9	6.6	0.30	2.9	1.5	1.5	1.4×10^{-2}
IRN	SASI	Very High	53	0.62	-2.6×10^{-2}	-3.8×10^{-2}	0.20	0.46	1.2	1.3	0.11
PAK	SASI	Very High	55	0.92	-2.7×10^{-2}	-0.10	9.5×10^{-2}	0.66	1.5	1.7	0.11
ISR	WASI	Very High	50	19	-7.9×10^{-2}	-3.8	-2.7	-10	2.0	2.1	4.0×10^{-2}
JOR	WASI	Very High	33	20	-8.9×10^{-2}	-6.9	-3.1	-7.5	2.6	2.6	3.5×10^{-2}
KWT	WASI	Very High	24	1.1×10^4	-4.6	-4.6×10^3	-6.2×10^3	-1.5×10^2	26	26	3.2×10^{-2}
SAU	WASI	Very High	31	-5.3	-5.2×10^{-3}	4.2	6.3	0.33	5.4	5.5	3.2×10^{-2}
OMN	WASI	Very High	22	1.9	-2.9×10^{-3}	-0.54	-0.61	0.12	0.85	0.88	2.7×10^{-2}
ARE	WASI	Very High	26	7.7×10^2	-2.0×10^{-3}	-2.0×10^2	-5.5×10^2	-4.8	23	23	3.3×10^{-2}
YEM	WASI	Very High	37	-6.7	-4.8×10^{-3}	6.0	2.4	1.3	2.9	2.9	3.5×10^{-2}
MDA	EEUR	Very High	43	0.49	1.4	4.7×10^{-2}	-0.50	1.4	2.8	2.8	4.1×10^{-2}
CZE	EEUR	Very High	45	-4.9	20	-0.99	15	-25	4.6	4.7	4.1×10^{-2}
DNK	NEUR	Very High	41	-0.45	0.16	9.5×10^{-2}	0.22	1.0	1.0	1.1	3.9×10^{-2}
EST	NEUR	Very High	33	-1.9×10^{-3}	-38	-0.62	-2.4	43	2.2	2.2	3.1×10^{-2}
MLT	SEUR	Very High	29	-12	-7.4×10^{-2}	6.6	-2.3	9.7	1.6	1.6	3.1×10^{-2}
SVN	SEUR	Very High	44	-8.5×10^{-3}	1.2×10^3	-45	-13	-1.1×10^3	1.2	1.3	3.8×10^{-2}
DEU	WEUR	Very High	44	-0.20	2.2	-8.8×10^{-2}	1.4	-1.6	1.7	1.8	4.1×10^{-2}
NLD	WEUR	Very High	41	-0.19	-3.9	-5.2×10^{-2}	-2.8	16	8.9	8.9	3.9×10^{-2}
BEL	WEUR	Very High	44	1.7	-19	-2.7×10^{-2}	-6.1	42	19	19	4.0×10^{-2}
LUX	WEUR	Very High	36	-0.46	-2.1×10^2	0.59	48	1.7×10^2	2.0	2.1	3.6×10^{-2}

Note: Each area name is abbreviated as follows: “EAFR”: Eastern Africa, “MAFR”: Middle Africa, “NAFR”: Northern Africa, “SAFR”: Southern Africa, “WAFR”: Western Africa, “NAME”: Northern America, “CAME”: Central America, “CARI”: Caribbean, “SAMI”: South America, “CASI”: Central Asia, “EASI”: Eastern Asia, “SASI”: Southern Asia, “SEASI”: South–Eastern Asia, “WASI”: Western Asia, “EEUR”: Eastern Europe, “NEUR”: Northern Europe, “SEUR”: Southern Europe, “WEUR”: Western Europe, and “AUNZ”: Australia & New Zealand. “SS_PB” is the sample size of the WBI^{PB} , “WBI_PB” is the WBI^{PB} , and “WBI_PB_0” is the standard value of the WBI^{PB} . Each factor (from $\Delta F1_PB$ to $\Delta F5_PB$) is aggregated in the same way as Figure 2. “ ΔFt_PB ” is calculated by summing from $\Delta F1_PB$ to $\Delta F5_PB$ and equal to the difference between WBI_PB and WBI_PB_0.

Table A2. Decomposition results of WBI^{CB} (unit: %).

Country	Area	Intensities	SS_CB	$\Delta F1_CB$	$\Delta F2_CB$	$\Delta F3_CB$	$\Delta F4_CB$	$\Delta F5_CB$	$\Delta F6_CB$	ΔFt_CB	WBI_CB	WBI_CB_0
MWI	EAFR	Very Low	725	2.0	-1.9×10^{-3}	3.0×10^{-2}	3.7×10^2	-5.7×10^2	2.0×10^2	-3.7×10^{-2}	4.7×10^{-2}	8.4×10^{-2}
MOZ	EAFR	Very Low	560	-1.5×10^{-3}	-4.2×10^{-4}	-1.8×10^{-3}	-1.8×10^{-2}	-0.13	0.12	-2.8×10^{-2}	5.8×10^{-2}	8.6×10^{-2}
TZA	EAFR	Very Low	1376	-0.16	-7.8×10^{-3}	2.6×10^{-2}	1.2×10^2	-1.2×10^2	0.28	8.9×10^{-3}	9.4×10^{-2}	8.5×10^{-2}
UGA	EAFR	Very Low	1031	-3.7	-1.8	0.11	6.0×10^2	-6.4×10^2	49	1.0×10^{-2}	9.4×10^{-2}	8.4×10^{-2}
ETH	EAFR	Very Low	1303	0.82	-3.9×10^{-3}	2.5×10^{-3}	-0.68	-0.37	0.21	-2.7×10^{-2}	6.1×10^{-2}	8.7×10^{-2}
ZMB	EAFR	Very Low	759	5.3×10^{-3}	-7.9×10^{-4}	-3.9×10^{-4}	0.32	-0.41	1.1×10^{-2}	-6.7×10^{-2}	2.0×10^{-2}	8.7×10^{-2}
AGO	MAFR	Very Low	746	4.8×10^{-2}	0.55	0.40	8.2×10^3	-8.2×10^3	2.1	-7.4×10^{-3}	7.9×10^{-2}	8.7×10^{-2}
CMR	MAFR	Very Low	1066	-1.1×10^{-2}	4.8×10^{-4}	5.0×10^{-4}	2.3	-2.4	3.8×10^{-2}	-6.9×10^{-2}	1.7×10^{-2}	8.6×10^{-2}
TCD	MAFR	Very Low	195	0.14	-1.2×10^{-3}	-1.6×10^{-2}	-0.14	-2.2×10^{-2}	-2.1×10^{-2}	-6.0×10^{-2}	2.2×10^{-2}	8.3×10^{-2}
COG	MAFR	Very Low	845	-7.2×10^{-3}	6.6×10^{-2}	1.6×10^{-2}	2.8×10^{-2}	-0.20	8.3×10^{-3}	-8.5×10^{-2}	1.1×10^{-3}	8.6×10^{-2}
GAB	MAFR	Very Low	569	-3.1×10^{-2}	1.7×10^{-2}	-6.7×10^{-6}	-3.5×10^{-3}	-5.1×10^{-2}	-7.9×10^{-3}	-7.7×10^{-2}	9.6×10^{-3}	8.6×10^{-2}
NAM	SAFR	Very Low	433	-1.8×10^{-2}	4.8×10^{-5}	-6.0×10^{-3}	0.23	-0.30	2.4×10^{-2}	-7.6×10^{-2}	1.1×10^{-2}	8.7×10^{-2}
GIN	WAFR	Very Low	602	-3.8×10^{-2}	1.7×10^{-2}	8.2×10^{-5}	8.0	-8.4	0.41	-1.4×10^{-2}	7.1×10^{-2}	8.5×10^{-2}
GNB	WAFR	Very Low	255	-3.3×10^{-2}	-3.3×10^{-3}	-1.2×10^{-3}	-3.7×10^{-3}	1.8×10^{-5}	2.0×10^{-2}	-2.1×10^{-2}	6.5×10^{-2}	8.6×10^{-2}
CAN	NAME	Very Low	4227	-9.3×10^{-3}	-4.1×10^{-2}	-1.6×10^{-2}	1.1	-17	16	-4.0×10^{-2}	4.7×10^{-2}	8.7×10^{-2}
USA	NAME	Very Low	6891	-4.9×10^{-3}	-0.35	-7.0×10^{-2}	0.66	-0.87	0.64	8.9×10^{-3}	9.6×10^{-2}	8.7×10^{-2}
BLZ	CAME	Very Low	522	-3.3×10^{-2}	2.9×10^{-4}	5.8×10^{-4}	1.3×10^{-2}	-2.8	2.7	-8.2×10^{-2}	3.6×10^{-3}	8.6×10^{-2}
CRI	CAME	Very Low	1466	-1.8×10^{-2}	8.4×10^{-3}	-1.0×10^{-4}	13	-13	7.2×10^{-2}	-5.0×10^{-2}	3.6×10^{-2}	8.6×10^{-2}
SLV	CAME	Very Low	815	0.14	2.8×10^{-3}	9.6×10^{-3}	9.0	-9.2	4.2×10^{-2}	-1.8×10^{-2}	6.7×10^{-2}	8.6×10^{-2}
GTM	CAME	Very Low	1405	-4.9×10^{-4}	2.1×10^{-2}	7.7×10^{-3}	29	-29	0.24	-6.2×10^{-2}	2.5×10^{-2}	8.6×10^{-2}
HND	CAME	Very Low	897	-7.2×10^{-3}	-1.5×10^{-4}	1.1×10^{-3}	2.2	-2.3	0.13	-5.6×10^{-2}	3.1×10^{-2}	8.6×10^{-2}
NIC	CAME	Very Low	808	-3.1×10^{-2}	8.4×10^{-4}	2.2×10^{-3}	26	-33	6.9	-7.1×10^{-2}	1.6×10^{-2}	8.7×10^{-2}
PAN	CAME	Very Low	1265	-3.7×10^{-2}	1.6×10^{-2}	6.3×10^{-3}	1.6	-1.7	2.5×10^{-2}	-6.8×10^{-2}	1.9×10^{-2}	8.7×10^{-2}
ARG	SAME	Very Low	3414	-4.4×10^{-3}	7.5×10^{-4}	-3.8×10^{-3}	8.5×10^4	-8.5×10^4	72	-7.3×10^{-2}	1.5×10^{-2}	8.7×10^{-2}
BOL	SAME	Very Low	845	-4.4×10^{-2}	1.4×10^{-3}	5.4×10^{-2}	37	-7.5×10^2	7.2×10^2	-8.3×10^{-2}	3.5×10^{-3}	8.6×10^{-2}
BRA	SAME	Very Low	3429	-3.6×10^{-2}	3.1×10^{-3}	-5.5×10^{-4}	3.6	-4.2	0.51	-7.5×10^{-2}	1.2×10^{-2}	8.7×10^{-2}
CHL	SAME	Very Low	2300	2.3×10^{-2}	3.2×10^{-3}	-7.5×10^{-4}	0.99	-1.5	0.44	-8.0×10^{-2}	7.1×10^{-3}	8.7×10^{-2}
COL	SAME	Very Low	1617	-5.2×10^{-2}	4.6×10^{-3}	-5.4×10^{-4}	8.2×10^{-2}	-0.40	0.29	-7.8×10^{-2}	8.1×10^{-3}	8.7×10^{-2}
ECU	SAME	Very Low	1203	-3.4×10^{-2}	-2.0×10^{-3}	-2.1×10^{-4}	11	-11	0.19	-6.7×10^{-2}	1.9×10^{-2}	8.7×10^{-2}
GUY	SAME	Very Low	720	4.8	7.3×10^{-2}	-0.60	-1.4	-2.6	-0.32	-8.4×10^{-2}	2.4×10^{-3}	8.6×10^{-2}
PRY	SAME	Very Low	908	7.5×10^{-2}	1.8×10^{-3}	-3.3×10^{-2}	4.6	-7.9×10^2	7.8×10^2	-8.3×10^{-2}	2.8×10^{-3}	8.6×10^{-2}
PER	SAME	Very Low	1714	-4.4×10^{-2}	-2.3×10^{-3}	6.1×10^{-4}	0.16	-0.25	5.9×10^{-2}	-7.6×10^{-2}	1.1×10^{-2}	8.7×10^{-2}
SUR	SAME	Very Low	727	1.0	3.2×10^{-4}	-2.5×10^{-2}	-0.35	-0.67	-4.8×10^{-2}	-8.0×10^{-2}	5.4×10^{-3}	8.6×10^{-2}
URY	SAME	Very Low	1432	1.1	3.2×10^{-2}	-0.20	4.8	-7.4	1.7	-8.1×10^{-2}	6.0×10^{-3}	8.7×10^{-2}

Table A2. Cont.

Country	Area	Intensities	SS_CB	$\Delta F1_CB$	$\Delta F2_CB$	$\Delta F3_CB$	$\Delta F4_CB$	$\Delta F5_CB$	$\Delta F6_CB$	ΔFt_CB	WBI_CB	WBI_CB_0
VEN	SAME	Very Low	1014	-5.0×10^{-2}	7.2×10^{-4}	9.2×10^{-4}	58	-58	4.0×10^{-2}	-7.8×10^{-2}	9.6×10^{-3}	8.7×10^{-2}
MNG	EASI	Very Low	523	-8.1×10^{-3}	4.4×10^{-2}	4.8×10^{-3}	0.28	-0.43	6.5×10^{-2}	-4.3×10^{-2}	4.4×10^{-2}	8.7×10^{-2}
BGD	SASI	Very Low	763	-1.6×10^{-4}	-1.3×10^{-2}	-8.4×10^{-3}	8.5×10^{-2}	-4.2×10^{-2}	-1.2×10^{-2}	9.0×10^{-3}	9.3×10^{-2}	8.4×10^{-2}
NPL	SASI	Very Low	768	2.2×10^{-3}	-2.1×10^{-2}	-2.1×10^{-3}	6.7×10^{-2}	-5.6×10^{-2}	1.2×10^{-2}	2.4×10^{-3}	8.9×10^{-2}	8.7×10^{-2}
MMR	SEASI	Very Low	384	-4.0×10^{-2}	-4.8×10^{-3}	-4.6×10^{-5}	0.11	-0.14	4.0×10^{-3}	-7.1×10^{-2}	1.3×10^{-2}	8.4×10^{-2}
IDN	SEASI	Very Low	2443	-1.8×10^{-3}	-9.4×10^{-3}	1.3×10^{-3}	1.1	-7.1×10^2	7.1×10^2	-1.5×10^{-2}	7.0×10^{-2}	8.5×10^{-2}
KHM	SEASI	Very Low	621	-4.3×10^{-2}	-4.2×10^{-3}	5.4×10^{-4}	17	-17	0.16	-6.2×10^{-2}	2.2×10^{-2}	8.4×10^{-2}
LAO	SEASI	Very Low	158	-5.9×10^{-2}	-3.1×10^{-3}	2.2×10^{-3}	1.9	-2.0	0.16	-7.3×10^{-2}	1.1×10^{-2}	8.4×10^{-2}
TLS	SEASI	Very Low	115	5.8×10^{-3}	-1.2×10^{-2}	-1.3×10^{-2}	1.0×10^{-2}	-4.9×10^{-3}	-1.9×10^{-2}	-3.2×10^{-2}	5.0×10^{-2}	8.2×10^{-2}
VNM	SEASI	Very Low	1787	-4.2×10^{-3}	-6.7×10^{-3}	4.8×10^{-3}	11	-1.9×10^3	1.9×10^3	-3.2×10^{-2}	5.4×10^{-2}	8.6×10^{-2}
GEO	WASI	Very Low	1296	-1.2×10^{-2}	1.0×10^{-2}	1.6×10^{-4}	0.13	-0.21	1.5×10^{-2}	-6.9×10^{-2}	1.8×10^{-2}	8.7×10^{-2}
BLR	EEUR	Very Low	1523	4.5×10^{-2}	0.26	1.0×10^{-2}	-7.2×10^{-2}	-0.24	-2.9×10^{-2}	-2.5×10^{-2}	6.1×10^{-2}	8.6×10^{-2}
ROU	EEUR	Very Low	2110	-4.4×10^{-3}	0.45	-6.3×10^{-4}	47	-48	0.22	-7.5×10^{-3}	7.9×10^{-2}	8.7×10^{-2}
RUS	EEUR	Very Low	3154	-3.5×10^{-2}	0.28	5.4×10^{-3}	3.9	-4.5	0.27	-5.0×10^{-2}	3.6×10^{-2}	8.6×10^{-2}
ISL	NEUR	Very Low	998	7.4×10^{-2}	1.2×10^{-3}	1.3×10^{-3}	-9.9×10^{-2}	-0.12	5.4×10^{-2}	-8.5×10^{-2}	7.5×10^{-4}	8.6×10^{-2}
IRL	NEUR	Very Low	2284	4.0×10^{-3}	0.57	-6.1×10^{-3}	-2.9×10^{-2}	-2.1	1.5	9.8×10^{-3}	9.7×10^{-2}	8.7×10^{-2}
LVA	NEUR	Very Low	1701	-9.1×10^{-3}	0.43	3.2×10^{-4}	0.14	-27	26	-3.8×10^{-2}	4.1×10^{-2}	7.9×10^{-2}
NOR	NEUR	Very Low	1903	-3.5×10^{-2}	2.2×10^{-2}	-3.2×10^{-4}	1.8	-2.2	0.38	-7.9×10^{-2}	7.4×10^{-3}	8.6×10^{-2}
ALB	SEUR	Very Low	1102	-4.8×10^{-3}	7.8×10^{-2}	5.4×10^{-3}	-1.2×10^{-2}	-6.7×10^{-2}	1.2×10^{-2}	1.1×10^{-2}	9.8×10^{-2}	8.7×10^{-2}
GRC	SEUR	Very Low	2683	3.1×10^{-2}	-2.5×10^{-3}	4.4×10^{-3}	15	-15	9.6×10^{-2}	-1.6×10^{-2}	7.1×10^{-2}	8.7×10^{-2}
PRT	SEUR	Very Low	2552	9.0×10^{-3}	-1.2×10^{-3}	4.8×10^{-3}	0.16	-0.26	8.6×10^{-2}	-2.4×10^{-3}	8.5×10^{-2}	8.7×10^{-2}
AUS	AUNZ	Very Low	3519	1.0×10^{-2}	5.9×10^{-3}	-5.0×10^{-3}	0.44	-3.9×10^2	3.9×10^2	-5.8×10^{-2}	2.9×10^{-2}	8.7×10^{-2}
NZL	AUNZ	Very Low	2526	0.27	1.3×10^{-3}	-2.9×10^{-2}	-0.10	-0.71	0.49	-8.1×10^{-2}	5.6×10^{-3}	8.7×10^{-2}
FJI	MELA	Very Low	770	-2.7×10^{-2}	4.3×10^{-3}	4.9×10^{-4}	0.18	-0.46	0.23	-7.5×10^{-2}	1.2×10^{-2}	8.7×10^{-2}
MDG	EAFR	Low	921	-3.0×10^{-2}	-1.1×10^{-2}	-4.5×10^{-3}	5.4×10^{-2}	-0.12	0.14	2.8×10^{-2}	0.11	8.2×10^{-2}
ZWE	EAFR	Low	837	1.0	-1.4×10^{-3}	4.0×10^{-2}	0.50	-1.9	0.37	5.1×10^{-2}	0.14	8.7×10^{-2}
RWA	EAFR	Low	558	4.7	4.3×10^{-3}	3.3×10^{-2}	2.3×10^2	-4.2×10^2	1.9×10^2	5.1×10^{-2}	0.13	8.4×10^{-2}
BWA	SAFR	Low	418	4.9×10^{-2}	0.12	0.11	1.1×10^2	-1.1×10^2	6.8×10^{-2}	8.9×10^{-2}	0.18	8.7×10^{-2}
SWZ	SAFR	Low	346	0.12	1.0×10^{-2}	2.0×10^{-2}	2.2	-2.3	-7.9×10^{-3}	1.8×10^{-2}	0.10	8.7×10^{-2}
GHA	WAFR	Low	1754	-2.6	2.3×10^{-3}	-0.27	4.7	-16	14	5.8×10^{-2}	0.14	8.5×10^{-2}
LBR	WAFR	Low	533	-5.0×10^{-2}	0.11	4.5×10^{-2}	2.8	-2.9	-1.4×10^{-2}	4.2×10^{-2}	0.13	8.4×10^{-2}
MLI	WAFR	Low	519	6.0×10^{-4}	-2.0×10^{-2}	-1.7×10^{-3}	8.6×10^{-3}	-2.4×10^{-2}	9.6×10^{-2}	6.0×10^{-2}	0.15	8.7×10^{-2}
MRT	WAFR	Low	662	0.41	-6.9×10^{-3}	-4.2×10^{-3}	-5.1×10^{-2}	-0.35	0.11	0.10	0.19	8.7×10^{-2}
NGA	WAFR	Low	1022	1.1	-3.7×10^{-2}	3.4×10^{-3}	4.7	-6.3	0.62	9.7×10^{-2}	0.18	8.6×10^{-2}

Table A2. Cont.

Country	Area	Intensities	SS_CB	$\Delta F1_CB$	$\Delta F2_CB$	$\Delta F3_CB$	$\Delta F4_CB$	$\Delta F5_CB$	$\Delta F6_CB$	ΔFt_CB	WBI_CB	WBI_CB_0
SEN	WAFR	Low	1383	-3.2×10^{-2}	-8.7×10^{-3}	1.4×10^{-2}	0.56	-2.0	1.5	9.3×10^{-2}	0.18	8.7×10^{-2}
SLE	WAFR	Low	418	-4.0×10^{-2}	8.4×10^{-2}	4.2×10^{-4}	-2.7×10^{-2}	-0.13	0.15	3.5×10^{-2}	0.12	8.5×10^{-2}
TGO	WAFR	Low	949	5.7	2.0	1.0	9.1	-17	-0.56	8.2×10^{-2}	0.17	8.6×10^{-2}
MEX	CAME	Low	2493	0.14	-1.3×10^{-3}	3.9×10^{-3}	2.4×10^{-2}	-0.27	0.14	2.4×10^{-2}	0.11	8.7×10^{-2}
JAM	CARI	Low	936	0.20	4.0×10^{-2}	3.8×10^{-3}	1.5×10^{-2}	-0.25	6.6×10^{-2}	7.2×10^{-2}	0.16	8.6×10^{-2}
KGZ	CASI	Low	795	8.6×10^{-2}	-6.2×10^{-3}	6.8×10^{-4}	5.3×10^{-2}	-0.14	3.5×10^{-2}	2.6×10^{-2}	0.11	8.7×10^{-2}
JPN	EASI	Low	2503	-1.9×10^{-2}	3.2×10^{-3}	3.2×10^{-2}	1.1	-1.2	9.1×10^{-2}	4.5×10^{-2}	0.13	8.7×10^{-2}
MYS	SEASI	Low	3244	-3.1×10^{-2}	0.11	4.1×10^{-5}	10	-11	0.15	5.8×10^{-2}	0.14	8.6×10^{-2}
PHL	SEASI	Low	2016	5.4×10^{-2}	-9.5×10^{-3}	0.48	6.4×10^4	-6.4×10^4	4.3	2.9×10^{-2}	0.11	8.3×10^{-2}
THA	SEASI	Low	3312	2.0×10^{-2}	2.5×10^{-2}	1.5×10^{-2}	2.2×10^3	-2.2×10^3	0.59	9.0×10^{-2}	0.18	8.7×10^{-2}
AZE	WASI	Low	1166	0.15	-1.2×10^{-3}	1.4×10^{-3}	-2.9×10^{-2}	-0.14	4.1×10^{-2}	2.4×10^{-2}	0.11	8.7×10^{-2}
TUR	WASI	Low	4002	0.52	-1.9×10^{-3}	4.4×10^{-2}	4.8×10^2	-4.8×10^2	0.13	8.3×10^{-2}	0.17	8.7×10^{-2}
HUN	EEUR	Low	2426	-2.3×10^{-3}	3.8	5.8×10^{-4}	3.6	-13	5.8	3.8×10^{-2}	0.13	8.7×10^{-2}
UKR	EEUR	Low	2700	0.46	0.55	4.9×10^{-3}	-7.7×10^{-2}	-1.9×10^3	1.9×10^3	2.0×10^{-2}	0.11	8.5×10^{-2}
LTU	NEUR	Low	1901	2.6×10^{-3}	1.7	-7.6×10^{-3}	5.4	-25	18	2.6×10^{-2}	0.11	8.6×10^{-2}
ITA	SEUR	Low	5602	0.50	5.9×10^{-2}	2.0×10^{-2}	2.9	-3.5	9.0×10^{-2}	9.2×10^{-2}	0.18	8.7×10^{-2}
CAF	MAFR	Moderate	354	-2.6×10^{-2}	1.9×10^2	8.7	-76	-6.2	-1.1×10^2	0.23	0.31	8.2×10^{-2}
MAR	NAFR	Moderate	1734	3.0	-4.8×10^{-3}	1.3×10^{-2}	-2.0	-0.99	0.22	0.29	0.37	8.7×10^{-2}
CIV	WAFR	Moderate	1545	0.35	0.31	1.9	3.1×10^5	-3.1×10^5	47	0.12	0.21	8.7×10^{-2}
NER	WAFR	Moderate	694	0.66	4.8×10^{-3}	7.2×10^{-4}	-0.28	-0.29	4.3×10^{-2}	0.14	0.22	8.7×10^{-2}
CUB	CARI	Moderate	652	0.25	8.0×10^{-3}	6.7×10^{-3}	1.8×10^4	-1.8×10^4	15	0.14	0.23	8.4×10^{-2}
LCA	CARI	Moderate	349	0.55	3.9×10^{-6}	-1.4×10^{-2}	-3.6×10^{-2}	-0.43	7.1×10^{-2}	0.14	0.22	8.5×10^{-2}
KAZ	CASI	Moderate	1454	2.5×10^{-2}	5.0×10^{-3}	1.0×10^{-2}	0.41	-0.68	0.39	0.15	0.24	8.7×10^{-2}
TJK	CASI	Moderate	336	4.2×10^{-3}	-7.0×10^{-3}	2.1×10^{-2}	0.18	-2.1×10^{-2}	8.0×10^{-2}	0.26	0.34	8.5×10^{-2}
TKM	CASI	Moderate	329	6.8×10^{-2}	-2.0×10^{-2}	1.7×10^{-3}	-1.4×10^{-2}	-1.0×10^{-2}	0.21	0.24	0.32	8.4×10^{-2}
CHN	EASI	Moderate	5681	0.34	8.8×10^{-3}	-4.6×10^{-4}	2.9×10^{-2}	-3.4	3.4	0.30	0.38	8.7×10^{-2}
PRK	EASI	Moderate	178	0.20	-5.7×10^{-3}	-3.1×10^{-2}	-1.3×10^{-2}	-3.0×10^{-2}	1.2×10^{-2}	0.13	0.22	8.4×10^{-2}
KOR	EASI	Moderate	2372	0.81	4.7×10^{-2}	-2.4×10^{-3}	36	-37	0.27	0.29	0.37	8.7×10^{-2}
AFG	SASI	Moderate	611	0.18	-1.7×10^{-2}	1.1×10^{-4}	4.6×10^{-2}	-2.7×10^{-2}	7.1×10^{-2}	0.25	0.34	8.4×10^{-2}
ARM	WASI	Moderate	1038	0.44	6.0×10^{-3}	3.4×10^{-3}	47	-48	4.4×10^{-2}	0.13	0.21	8.7×10^{-2}
IRQ	WASI	Moderate	735	0.32	-1.6×10^{-3}	-3.2×10^{-3}	-7.3×10^{-3}	-0.19	2.4×10^{-2}	0.15	0.23	8.7×10^{-2}
BGR	EEUR	Moderate	2499	-0.23	-1.8	-0.13	41	-67	29	0.24	0.33	8.7×10^{-2}
SVK	EEUR	Moderate	1688	-1.2×10^{-3}	5.0	-2.2×10^{-2}	5.6	-11	0.22	0.18	0.27	8.7×10^{-2}
FIN	NEUR	Moderate	1750	-1.7×10^{-2}	16	-9.4×10^{-3}	-4.3	-2.1×10^5	2.1×10^5	0.24	0.32	8.6×10^{-2}

Table A2. Cont.

Country	Area	Intensities	SS_CB	$\Delta F1_CB$	$\Delta F2_CB$	$\Delta F3_CB$	$\Delta F4_CB$	$\Delta F5_CB$	$\Delta F6_CB$	ΔFt_CB	WBI_CB	WBI_CB_0
SWE	NEUR	Moderate	2834	-1.5×10^{-2}	4.1	-2.2×10^{-2}	17	-77	57	0.18	0.27	8.7×10^{-2}
HRV	SEUR	Moderate	1828	-2.0×10^{-2}	33	-9.6×10^{-3}	5.8	-35	-3.5	0.23	0.31	8.7×10^{-2}
MKD	SEUR	Moderate	1311	0.53	0.71	4.1×10^{-3}	1.9	-2.4	-0.64	0.13	0.21	8.7×10^{-2}
ESP	SEUR	Moderate	4953	0.15	1.9×10^{-3}	-4.5×10^{-3}	14	-14	0.30	0.17	0.25	8.7×10^{-2}
CHE	WEUR	Moderate	2878	5.9×10^{-2}	2.0	-4.7×10^{-2}	8.8	-11	7.5×10^{-3}	0.30	0.38	8.7×10^{-2}
KEN	EAFR	High	1555	58	-2.2×10^{-2}	1.1	-27	-36	4.3	0.55	0.64	8.7×10^{-2}
MUS	EAFR	High	1129	0.87	3.0×10^{-3}	9.1×10^{-4}	0.13	-0.72	0.40	0.68	0.76	8.7×10^{-2}
SDN	NAFR	High	844	3.2	-7.3×10^{-3}	9.9×10^{-3}	-1.7	-1.2	0.19	0.54	0.63	8.6×10^{-2}
ZAF	SAFR	High	3485	3.0	3.9×10^{-2}	6.2×10^{-3}	3.8	-6.6	9.3×10^{-2}	0.34	0.43	8.7×10^{-2}
BEN	WAFR	High	829	0.64	0.18	4.7×10^{-3}	32	-33	0.66	0.39	0.47	8.4×10^{-2}
GMB	WAFR	High	941	0.17	0.14	3.1×10^{-3}	5.5×10^{-3}	3.9×10^{-2}	0.13	0.48	0.57	8.7×10^{-2}
BFA	WAFR	High	799	4.2	-0.20	1.1×10^{-2}	0.31	-4.1	0.13	0.35	0.44	8.6×10^{-2}
DOM	CARI	High	823	0.31	-6.5×10^{-3}	-4.2×10^{-3}	0.76	-1.1	0.39	0.33	0.42	8.6×10^{-2}
GRD	CARI	High	436	-4.9	-5.0	-0.20	0.58	9.2	0.67	0.38	0.47	8.7×10^{-2}
HTI	CARI	High	480	-2.1	-3.6×10^{-3}	0.22	-0.47	3.3	-0.49	0.42	0.51	8.5×10^{-2}
UZB	CASI	High	582	0.17	-1.1×10^{-2}	3.7×10^{-3}	0.65	-0.59	0.12	0.34	0.43	8.7×10^{-2}
LKA	SASI	High	1575	0.43	-1.2×10^{-2}	1.4×10^{-2}	36	-36	0.29	0.54	0.63	8.5×10^{-2}
IND	SASI	High	4481	0.48	-1.7×10^{-2}	-1.4×10^{-2}	1.6×10^2	-1.6×10^2	0.95	0.58	0.67	8.7×10^{-2}
CYP	WASI	High	1936	4.5	8.9×10^{-3}	0.19	2.8	-8.2	1.3	0.63	0.72	8.7×10^{-2}
LBN	WASI	High	2796	2.8	6.9×10^{-2}	5.7×10^{-4}	1.4	-3.7	8.5×10^{-2}	0.69	0.78	8.7×10^{-2}
POL	EEUR	High	3385	-0.94	0.11	-4.8×10^{-2}	54	-68	15	0.47	0.56	8.7×10^{-2}
DNK	NEUR	High	3239	-0.70	-1.1	-4.6×10^{-2}	33	-46	15	0.64	0.72	8.7×10^{-2}
GBR	NEUR	High	5114	-2.6	-3.0	4.4×10^{-3}	3.3	-0.10	3.0	0.52	0.61	8.7×10^{-2}
AUT	WEUR	High	3278	-1.0×10^{-3}	20	-0.12	-2.3	-25	7.9	0.64	0.72	8.7×10^{-2}
FRA	WEUR	High	5890	-1.3	-0.94	5.6×10^{-3}	4.2	-15	13	0.51	0.59	8.7×10^{-2}
DJI	EAFR	Very High	441	7.2	4.8	0.73	-1.3	6.2	3.6	21	21	8.7×10^{-2}
DZA	NAFR	Very High	1233	7.3×10^2	62	-0.20	-3.4×10^2	-4.5×10^2	1.1	1.2	1.3	8.7×10^{-2}
EGY	NAFR	Very High	3206	1.4	-1.1×10^{-2}	2.9×10^{-2}	32	-33	0.42	1.7	1.8	8.7×10^{-2}
TUN	NAFR	Very High	1446	9.3	2.3×10^{-4}	2.8×10^{-3}	-2.3	-6.6	0.43	0.83	0.91	8.6×10^{-2}
LSO	SAFR	Very High	45	0.11	0.86	2.5×10^{-2}	0.67	9.4×10^{-2}	-0.36	1.4	1.5	8.0×10^{-2}
CPV	WAFR	Very High	594	-0.73	1.3×10^{-2}	0.18	0.36	1.1	-9.3×10^{-2}	0.83	0.92	8.7×10^{-2}
ATG	CARI	Very High	541	-0.47	-2.6	-0.32	3.8	1.9	0.13	2.5	2.6	8.7×10^{-2}
BRB	CARI	Very High	862	9.3	8.6×10^{-3}	3.7×10^{-2}	1.0×10^2	-1.1×10^2	2.2×10^{-2}	1.4	1.5	8.7×10^{-2}
DMA	CARI	Very High	341	-2.0	-3.8	-0.12	0.27	7.5	-0.58	1.2	1.3	8.4×10^{-2}

Table A2. Cont.

Country	Area	Intensities	SS_CB	$\Delta F1_CB$	$\Delta F2_CB$	$\Delta F3_CB$	$\Delta F4_CB$	$\Delta F5_CB$	$\Delta F6_CB$	ΔFt_CB	WBI_CB	WBI_CB_0
KNA	CARI	Very High	310	−7.6	2.4	−0.66	12	42	−0.41	49	49	8.6×10^{-2}
TTO	CARI	Very High	1142	−4.4	−3.2	7.3×10^{-4}	0.54	7.9	0.91	1.7	1.8	8.6×10^{-2}
IRN	SASI	Very High	1760	0.51	-1.1×10^{-2}	1.1×10^{-2}	1.7	−1.5	0.42	1.1	1.2	8.5×10^{-2}
PAK	SASI	Very High	2102	0.66	1.5×10^{-2}	8.8×10^{-3}	0.86	−0.89	0.29	0.93	1.0	8.6×10^{-2}
ISR	WASI	Very High	2344	11	−1.7	-5.4×10^{-2}	3.7×10^2	-3.8×10^2	4.0	2.5	2.6	8.7×10^{-2}
JOR	WASI	Very High	1710	1.3×10^2	1.3	1.4	−22	-1.0×10^2	1.4	5.8	5.8	8.7×10^{-2}
KWT	WASI	Very High	1161	-1.5×10^3	6.4	−5.9	−36	1.5×10^3	2.5×10^2	3.0×10^2	3.0×10^2	8.5×10^{-2}
SAU	WASI	Very High	1958	30	1.4×10^{-3}	-4.2×10^{-2}	26	−45	0.80	12	12	8.5×10^{-2}
OMN	WASI	Very High	1401	1.2	-1.6×10^{-3}	-1.7×10^{-2}	14	−11	0.67	4.9	5.0	8.7×10^{-2}
ARE	WASI	Very High	2556	1.3×10^2	3.0×10^{-2}	−4.9	7.9×10^2	-8.6×10^2	−17	41	41	8.5×10^{-2}
YEM	WASI	Very High	1007	72	-3.8×10^{-3}	1.7	−11	−57	0.54	5.8	5.9	8.7×10^{-2}
MDA	EEUR	Very High	1417	−1.3	8.7	1.3	2.1×10^3	-2.9×10^3	7.8×10^2	2.0	2.0	8.7×10^{-2}
CZE	EEUR	Very High	2383	−16	74	−0.36	7.6×10^2	-2.9×10^3	2.1×10^3	11	11	7.9×10^{-2}
EST	NEUR	Very High	1432	-1.5×10^{-3}	9.8×10^2	−0.45	6.0×10^2	-1.7×10^3	83	4.0	4.1	8.7×10^{-2}
MLT	SEUR	Very High	1041	29	−2.6	−0.19	−10	−19	5.6	3.0	3.1	8.7×10^{-2}
SVN	SEUR	Very High	1745	-7.4×10^{-3}	1.3×10^3	−0.34	56	-5.8×10^2	-7.7×10^2	2.5	2.6	8.7×10^{-2}
DEU	WEUR	Very High	5860	−2.9	11	-7.4×10^{-2}	9.9	−58	42	2.7	2.8	8.7×10^{-2}
NLD	WEUR	Very High	6038	8.3	98	−1.2	4.8×10^2	-6.6×10^2	81	6.2	6.3	8.7×10^{-2}
BEL	WEUR	Very High	4982	71	1.4×10^2	−11	1.2×10^3	-1.4×10^3	70	21	21	8.7×10^{-2}
LUX	WEUR	Very High	889	−3.3	-5.7×10^2	−1.7	−50	−43	6.7×10^2	5.7	5.8	8.6×10^{-2}

Note: Each area name is abbreviated in the same way as Table A1. “SS_CB” is the sample size of the WBI^{CB} , “WBI_CB” is the WBI^{CB} , and “WBI_CB_0” is the standard value of the WBI^{CB} . Each factor (from $\Delta F1_CB$ to $\Delta F6_CB$) is calculated in the same way as Figure 2. “ ΔFt_CB ” is aggregated by summing from $\Delta F1_CB$ to $\Delta F6_CB$ and equal to the difference between WBI_CB and WBI_CB_0.

References

- Shen, Y.; Oki, T.; Utsumi, N.; Kanae, S.; Hanasaki, N. Projection of future world water resources under SRES scenarios: Water withdrawal. *Hydrol. Sci. J.* **2008**, *53*, 11–33. [\[CrossRef\]](#)
- Hoekstra, A.Y.; Hung, P.Q. Introduction. In *Virtual Water Trade: A Quantification of Virtual Water Flows between Nations in Relation to International Crop Trade, Value of Water Research Report Series No.11*; UNESCO-IHE: Delft, The Netherlands, 2002; pp. 9–12.
- International Organization for Standardization (ISO). ISO 14046 Briefing Note. Available online: https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/iso14046_briefing_note.pdf (accessed on 27 September 2020).
- Hoekstra, A.Y.; Chapagain, A.K.; Aldaya, M.M.; Mekonnen, M.M. Water Footprint Accounting. In *The Water Footprint Assessment Manual—Setting the Global Standard*; Earthscan: London, UK, 2011; pp. 19–72.
- Raskin, P.; Gleick, P.; Kirshen, P.; Pontius, G.; Strzepek, K. Future Water Stress and Vulnerability. In *Comprehensive Assessment of the Freshwater Resources of the World; Water Futures: Assessment of Long-Range Patterns and Problems*; Stockholm Environment Institute: Stockholm, Sweden, 1997; pp. 22–39.
- Hanasaki, N.; Kanae, S.; Oki, T.; Masuda, K.; Motoya, K.; Shirakawa, N.; Shen, Y.; Tanaka, K. An integrated model for the assessment of global water resources—Part 2: Applications and assessments. *Hydrol. Earth Syst. Sci.* **2008**, *12*, 1027–1037. [\[CrossRef\]](#)
- Alcamo, J.; Flörke, M.; Märker, M. Future long-term changes in global water resources driven by socio-economic and climatic changes. *Hydrol. Sci. J.* **2007**, *52*, 247–275. [\[CrossRef\]](#)
- Sun, S.; Wang, Y.; Engel, B.A.; Wu, P. Effects of virtual water flow on regional water resources stress: A case study of grain in China. *Sci. Total Environ.* **2016**, *550*, 871–879. [\[CrossRef\]](#)
- Hoekstra, R.; van der Bergh, J.J.C.J.M. Comparing structural and index decomposition analysis. *Energy Econ.* **2003**, *25*, 39–64. [\[CrossRef\]](#)
- Ang, B.W.; Liu, F.L. A new energy decomposition method: Perfect in decomposition and consistent in aggregation. *Energy* **2001**, *26*, 537–548. [\[CrossRef\]](#)
- Sun, J.W. Changes in energy consumption and energy intensity: A complete decomposition model. *Energy Econ.* **1998**, *20*, 85–100. [\[CrossRef\]](#)
- Sun, J.W.; Malaska, P. CO₂ emission intensities in developed countries 1980–1994. *Energy* **1998**, *23*, 105–112. [\[CrossRef\]](#)
- Ang, B.W.; Liu, F.L.; Chew, E.P. Perfect decomposition techniques in energy and environmental analysis. *Energy Policy* **2003**, *31*, 1561–1566. [\[CrossRef\]](#)
- Mishina, Y.; Muromachi, Y. Regional decomposition analysis of CO₂ emissions from passenger cars and trucks in Japan from 1999 to 2008. *J. Jpn. Soc. Civ. Eng. Ser. D3 Infrastruct. Plan. Manag.* **2011**, *67*, I_89–I_100. (In Japanese)
- Mishina, Y.; Muromachi, Y. Carbon dioxide emissions from Japanese passenger cars up to 2020: Projection using modified Lapeyres decomposition techniques. *J. East Asia Soc. Transp. Stud.* **2013**, *10*, 1157–1170.
- Ang, B.W. Decomposition analysis for policymaking in energy: Which is the preferred method? *Energy Policy* **2004**, *32*, 1131–1139. [\[CrossRef\]](#)
- Xu, Y.; Huang, K.; Yu, Y.; Wang, X. Changes in water footprint of crop production in Beijing from 1978 to 2012: A logarithmic mean Divisia index decomposition analysis. *J. Clean. Prod.* **2015**, *87*, 180–187. [\[CrossRef\]](#)
- Zhao, C.; Chen, B. Driving force analysis of the agricultural water footprint in China based on the LMDI method. *Environ. Sci. Technol.* **2014**, *48*, 12723–12731. [\[CrossRef\]](#)
- Zou, M.; Kang, S.; Niu, J.; Lu, H. A new technique to estimate regional irrigation water demand and driving factor effects using an improved SWAT model with LMDI factor decomposition in an arid basin. *J. Clean. Prod.* **2018**, *185*, 814–828. [\[CrossRef\]](#)
- Zhang, Z.; Shi, M.; Yang, H. Understanding Beijing's water challenge: A decomposition analysis of changes in Beijing's water footprint between 1997 and 2007. *Environ. Sci. Technol.* **2012**, *46*, 12373–12380. [\[CrossRef\]](#) [\[PubMed\]](#)
- Wang, X.; Huang, K.; Yu, Y.; Hu, T.; Xu, Y. An input-output structural decomposition analysis of changes in sectoral water footprint in China. *Ecol. Indic.* **2016**, *69*, 26–34. [\[CrossRef\]](#)
- Feng, L.; Chen, B.; Hayat, T.; Alsaedi, A.; Ahmad, B. The driving force of water footprint under the rapid urbanization process: A structure decomposition analysis for Zhangye city in China. *J. Clean. Prod.* **2017**, *163*, S322–S328. [\[CrossRef\]](#)
- Sun, S.; Fu, G.; Bao, C.; Fang, C. Identifying hydro-climatic and socioeconomic forces of water scarcity through structural decomposition analysis: A case study of Beijing city. *Sci. Total Environ.* **2019**, *687*, 590–600. [\[CrossRef\]](#)
- Zhang, C.; Wu, Y.; Yu, Y. Spatial decomposition analysis of water intensity in China. *Socio-Econ. Plan. Sci.* **2020**, *69*, 100680. [\[CrossRef\]](#)
- Yamaguchi, Y.; Yoshikawa, N.; Amano, K.; Hashimoto, S. Evaluation of current freshwater requirement in Asia based on global food trade and food supply-demand balances. *Asia Jpn. Res. Acad. Bull.* **2019**, *1*, 11.
- Stone, R.; Bates, J.; Bacharach, M. Changing Coefficients. In *Input-Output Relationships 1954–1966, A Programme for Growth*; Chapman and Hall Ltd.: London, UK, 1963; Volume 3, pp. 24–41.
- Food and Agriculture Organization of the United Nations (FAO). Concepts and Definitions Used in Food Balance Sheets. In *Food Balance Sheet: A Handbook*; FAO: Rome, Italy, 2001; pp. 8–18.
- Mekonnen, M.M.; Hoekstra, A.Y. *National Water Footprint Accounts: The Green, Blue and Grey Water Footprint of Production and Consumption, Value of Water Research Report Series No. 50*; UNESCO-IHE: Delft, The Netherlands, 2011; Volume 2.

29. Döll, P.; Siebert, S. Global modeling of irrigation water requirements. *Water Resour. Res.* **2002**, *38*, 8–1–8–10. [CrossRef]
30. Smakhtin, V.; Revenga, C.; Döll, P. Data and Methodology. In *Taking into Account Environmental Water Requirements in Global-Scale Water Resources Assessments, Comprehensive Assessment of Water Management in Agriculture Research Report 2*; Comprehensive Assessment Secretariat: Colombo, Sri Lanka, 2004; pp. 3–10.
31. FAO. FAOSTAT: Food Balances: Commodity Balances—Crops Primary Equivalent, 2009–2011. Available online: <http://www.fao.org/faostat/en/#data/BC> (accessed on 19 January 2018).
32. FAO. FAOSTAT: Food Balances: Commodity Balances—Livestock and Fish Primary Equivalent, 2009–2011. Available online: <http://www.fao.org/faostat/en/#data/BL> (accessed on 19 January 2018).
33. FAO. FAOSTAT: Trade: Detailed Trade Matrix, 2009–2011. Available online: <http://www.fao.org/faostat/en/#data/TM> (accessed on 1 April 2017).
34. FAO. AQUASTAT, 2009–2011. Available online: <http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en> (accessed on 9 May 2017).
35. Ministry of Education, Culture, Sports, Science and Technology (MEXT). Standard Tables of Food Composition in Japan—2010. Available online: https://www.mext.go.jp/b_menu/shingi/gijyutu/gijyutu3/houkoku/1298713.htm (accessed on 27 March 2018). (In Japanese)
36. MEXT. Standard Tables of Food Composition in Japan—2015—(Seventh Revised Version). Available online: https://www.mext.go.jp/a_menu/syokuhinseibun/1365297.htm (accessed on 26 July 2019). (In Japanese)
37. United States Department of Agriculture (USDA). FoodData Central—USDA. Available online: <https://fdc.nal.usda.gov/> (accessed on 16 October 2019).
38. INRAE-CIRAD-AFZ. Tables of Composition and Nutritional Values of Feed Materials INRA CIRAD AFZ. Available online: <https://www.feedtables.com/> (accessed on 13 October 2019).
39. Japan Association for International Collaboration of Agriculture and Forest (JAICAF). “Nishi Afurika no nōgyō to mamerui” [Agriculture and Beans of West Africa]. In “Nishi Afurika ni okeru mamerui no seisan kara ryūtū made—Benan Kyōwakoku no jirei kara ikinai shijō to chīki jūmin no seikatsu kōjō o kangaeru” [From Production to Distribution of Beans in West Africa—Thinking Intra-Regional Market and Life Improvement of Local Residents from the Case of the Republic of Benin]; JAICAF: Tokyo, Japan, 2007; pp. 3–52. (In Japanese)
40. Agricultural & Livestock Industries Corporation (ALIC). Statistical Data Regarding Supply-Demand Relationship of Livestock. Available online: https://www.alic.go.jp/joho-c/joho05_000073.html (accessed on 9 October 2019). (In Japanese)
41. FAO. FAOSTAT: Population: Annual Population, 2010. Available online: <http://www.fao.org/faostat/en/#data/OA> (accessed on 24 September 2019).
42. FAO. Introduction. In *The FAO Statistics Quality Assurance Framework*; FAO: Rome, Italy, 2014; p. 5.