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THE VIRTUAL WATER OF SIBERIA AND THE RUSSIAN FAR EAST FOR THE ASIA-PACIFIC REGION: GLOBAL GAINS VS REGIONAL SUSTAINABILITY

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THE VIRTUAL WATER OF SIBERIA AND THE RUSSIAN FAR EAST FOR THE ASIA-PACIFIC REGION: GLOBAL GAINS VS REGIONAL SUSTAINABILITY[3]

Though Siberia and the Russian Far East are often considered oil and gas reservoirs, the southern areas of these regions have significant potential for water-intensive production, such as agricultural goods, chemicals, pulp and paper, metals, hydro energy. This potential is strengthening due to the proximity of the most dynamic and water demanding region of the world—the Asian-Pacific region (APR), where the challenge of water and food security is recognized as strategic. Russian political discourse has always been determined by a Eurocentric focus which has seriously constrained intensive cooperation with Asia. This paper investigates the opportunities and challenges to Siberia and the Russian Far East from the perspective of interdependence theory and its water specification—the virtual water concept. The most significant outcomes of the research refer to both theory and strategy. We show that in some cases the virtual water trade may help the water economy on a global scale but worsen the long-term regional water security status and increase the level of water stress in particular areas. The implication for Russia and APR is that Russia's integration into the APR virtual water market would provide considerable benefits for Russia which include economic gains. More importantly, according to the interdependence theory, as well as a defensive realism, Russia, acting as a guarantor of Asia's food and water security, would provide long-term positive effects for the whole APR through reduced water stress, and the desecuritization of the food trade and water allocation in the region.

JEL: F50; F18; Q25.

Keywords: virtual water, water scarcity; Asia-Pacific, Russian Far East, international trade, food security

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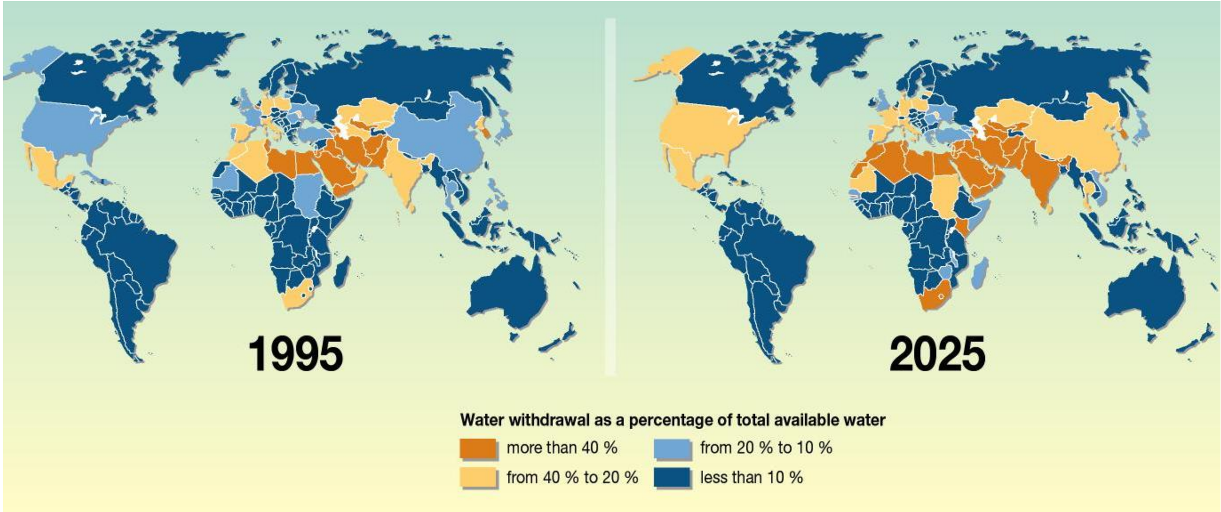
1. **Introduction**

Freshwater stress already affects 1.9 billion people worldwide, and UN forecasts say that two-thirds of the Earth's population will be experiencing it by 2050[4]. Governments, international organizations, NGOs and scholars are paying increased attention to the challenge of water scarcity which is one of the main threats to international security and sustainability. A special focus of this research is a case study of South and East Asia with China, India and other Asia Pacific region (APR) countries as the most illustrative examples. Since the 1990s, water stress has risen dramatically in nearly all the countries of this region (*Picture 1*).



Pic.1 Countries Facing Water Stress in 1995 and Projected in 2025

Source: http://www.grida.no/graphicslib/

For the last two decades, increased water scarcity and globalization have contributed to the establishment of water as a new economic dimension. Independent states have started to consider fresh water as an economic good, which is becoming more and more valuable[5]. With this new vision, a need for comprehensive governance of water resources has appeared. As most key freshwater basins are transboundary, this governance has passed from the national to the supra-national level[6]. However the role of states in this governance is crucial and is determined by the strong interconnection between water resources, territory and sovereignty rights. It makes perfect sense that in competing for an economic resource, states may use both soft and hard power, that is apply both cultural and economic, and military instruments. Citing Sen "apolitical food problems do not exist"[7], Lopez-Gunn et al. expand this to the water problem as well[8]. Actually, any state takes responsibility for providing national food and water security—and this makes its active participation in water and food markets unavoidable.

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[4] WWAP (2009). *The United Nations World Water Development Report 3 (WWDR3): Water in a changing world.* World Water Assessment Program, UNESCO, London.

[5] Rogers, P., Bhatia, R., & Huber, A. (1998). *Water as a social and economic good: How to put the principle into practice.* Stockholm, Sweden: Global Water Partnership/Swedish International Development Cooperation Agency.

[6] Lowi, M. R. (1995). *Water and power: The politics of a scarce resource in the Jordan River basin* (Vol. 31). Cambridge University Press.

[7] Sen, A. (1982). The food problem: Theory and policy. *Third World Quarterly*, 4(3), 447-459.

[8] Lopez-Gunn, E., De Stefano, L., & Llamas, M. R. (2012). The role of ethics in water and food security: balancing utilitarian and intangible values. *Water Policy*, 14(1), 89-105.

Carr, wrote that “the fundamental problem of world politics is to stimulate the peaceful evolution of relations between the satisfied and unsatisfied parts without armed force”[9]. Relative to the water problem it means that in the water sector is unique, as the number of unsatisfied participants is constantly increasing, all peaceful forms of state interaction (such as the virtual water trade, technological trade, desalination initiatives, bulk water trade) represent a means to avoid a water conflict. Despite unprecedented global attention to water problems, there is not yet any international legislation framework on transboundary water use which could be applied as a base for global water governance (a UN Convention on the Law of the Non-Navigational Uses of International Watercourses failed in 1997).

At the moment global consensus relates only to access to drinking water and sanitation. Specifically, sustainable access to safe drinking water and basic sanitation by 2015 was one of UN Millennium development goals. Moreover, the decade from 2005 to 2015 was chosen as a decade of action for “Water for life”. Some progress in this area has been achieved, mostly by increasing access to improved drinking water in rural areas of South and East Asia. At the same time, the water overexploitation issue as an urgent challenge for local water sustainability has strengthened in virtue of population and economic growth, the protein revolution and urbanization in developing countries.[10]

2. The case study and basic assumptions

This paper has six sections. After Section 1 the introduction, Section 2 presents our research question, hypothesis and the choice of case study. Section 3 has the literature review, focused on the virtual water theory, its implications and critics, and on the interdependence theory which represents a broader framework of the virtual water concept.

Section 4 describes our research framework, the data used, and methods applied. Section 5 presents the most important results—the estimates and interpretation of intraregional virtual water trade flows within APR. Finally, Section 6 reviews our hypothesis and provides some discussion about future recommendations and forecasts related to regional development and water management. Some theoretical output is provided as well. As the water problem is closely tied both to theoretical concepts and to policy making, our conclusions reflect this dichotomy.

This paper examines primarily three research questions: 1) what is the position of the richest Eurasian water power (Russia) towards its APR neighbors in terms of virtual water trade? 2) how may virtual water trade become a source of regional long-term sustainability? and finally, 3) how Russian power in APR can be increased because of water resources?

As the research focuses on the virtual water trade it is important to clarify what we mean by this term. The virtual water concept was introduced by Allan[11] and represents virtual water trade (also known as trade in embedded or embodied water) that refers to the hidden flow of water if

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[9] Carr, E. H., Cox, M. (1964). *The twenty years' crisis, 1919-1939: an introduction to the study of international relations* (Vol. 1122). New York: Harper & Row.

[10] WWAP (2012). *The United Nations World Water Development Report 4 (WWDR4): Managing Water Under Uncertainty and Risk* (Vol. 3) World Water Assessment Program, UNESCO, Paris.

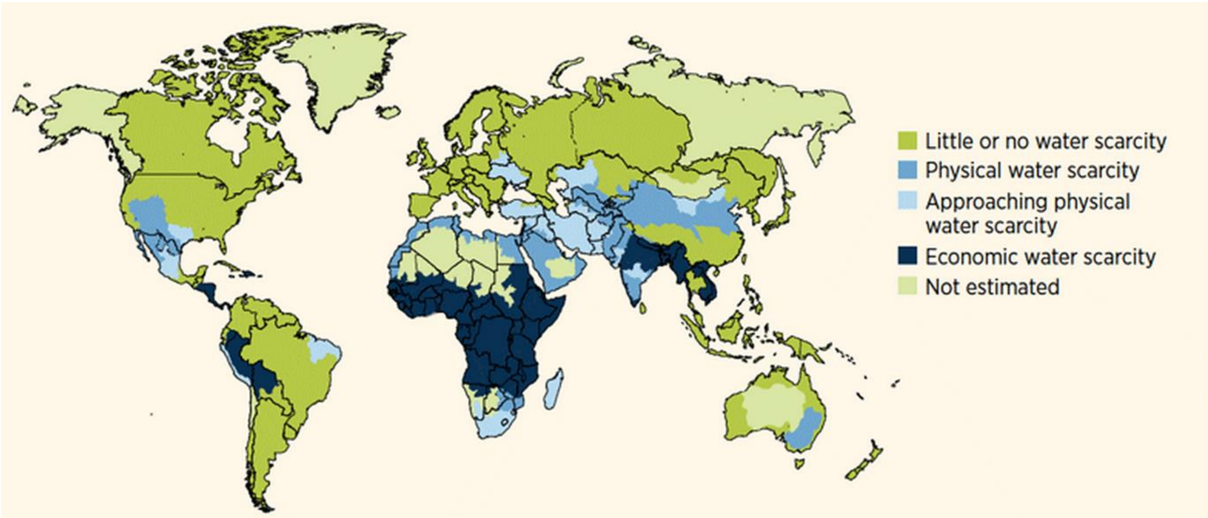
[11] Allan, J.A. (2003). Virtual water-the water, food, and trade nexus. Useful concept or misleading metaphor?. *Water International*, 28(1), 106-113.

food or other commodities are traded from one place to another. For arid regions imports of virtual water (mainly through agriculture which accounts up to 80% of water use) could be an efficient instrument to decrease local demand and reallocate water to competitively more favourable sectors, i.e. to mitigate water stress[12]. The potential volume of water savings due to the trade of water-intensive goods is large: for instance, to produce 1 ton of soybeans requires 4124 m^3 of water in India, 2030 in Indonesia, 1076 in Brazil. For meat production, the water component differs even more: 1 ton of beef needs 11681 m^3 in the Netherlands, 21028 m^3 in Russia and 37762 m^3 in Mexico[13].

There are two main tracks of how the virtual water concept can be applied. According to the first understanding it addresses exports from water abundant to water deficient countries, such as from Russia to APR. According to the second understanding virtual water concept suggests exports from countries where water efficiency is higher (i.e. they use less water to produce a same amount of goods). The second case creates direct savings in water, but on a regional scale, the first option is more sustainable. Our research hypothesis refers to this paradox. We suggest that virtual water trade in some cases may improve water economy on a global scale but worsen long-term regional water security status and increase the level of water stress in particular areas. This paradox grows from the fact that the water problem when considered globally, has a deeper regional or local influence.

Case study justification

Russia ranks second in the world after Brazil by renewable water resources, while the list of developing countries suffering from water scarcity, includes some of Russia's immediate neighbours including Central Asian states, China and Mongolia (*Picture 2*). In China alone, a total of 560 rivers are drying out; the Yellow River failed to reach its mouth in 1997. (See Appendix A for detailed data on available water resources (Table A1) and structure of water use (Table A2) in top-10 world water possessors and users).



[12] Allan, J.A. (2002). *The Middle East water question: Hydropolitics and the global economy* (Vol. 2). Ib Tauris.
[13] Hoekstra, A. Y., Chapagain, A. K. (2007). Water footprints of nations: water use by people as a function of their consumption pattern. *Water resources management*, 21(1), 35-48.

Pic.2 Global physical and economic water scarcity

Source: www.un.org

China ranks sixth in the world in terms of available water resources but has the largest population and second largest economy and therefore faces the acute water stress. Available water resources are insufficient for the growing needs of agriculture, industrial production and the energy sector. There is a similar situation in some other APR countries where growing water use in agriculture and industries producing foodstuffs and commodities provides additional load on limited water resources. In the political sense, there is clear demand from China, ASEAN countries (whose dependence on China is growing), Japan and Korea Republic, for additional sources of food imports and diversification of suppliers for ensuring national food security.

First published in 2014, CPC Central document №1, declared the strengthening of national food security and agriculture support in the deteriorating environmental conditions as China's top priority[14]. ASEAN since 2009 has been operating a four-year plan to ensure food security: ASEAN Integrated Food Security Framework and Strategic Plan of Action on Food Security in ASEAN Region[15]. The Japanese Government in 2010 made the New Basic Plan for Food, Agriculture and Rural Areas, where the goal of self-improving food security from 40 to 50% by 2020 was set[16]. The Republic of Korea, which imports more than 90% of its food, has invested in agro-colonization: a Korean food-importing conglomerate operating in 16 countries.[17]

At the same time the Asian part of Russia is the most water-abundant region on the whole Asian continent. 72% of all the Russia's freshwater resources are located in Siberia and the Russian Far East. The lake Baikal alone contains about 20% of the global fresh water. Since Soviet times the gap in water abundance between Siberia and neighbouring countries has been frequently used to justify plans of water exports from this Russian region. These plans have never been executed because of the technical complexity and economical irrationality (for example costs of the Ob river transfer to Central Asia are estimated in at least $140 bn[18]). These factors and the large potential environmental damage make any projects of water exports from Russia utopian. Yet Russia may use its water abundance by taking on the leading role in the market of virtual water by exporting agricultural and other water-retaining products.

Russia's opportunities for exporting virtual water strengthened with the 'turn to the East' in Russian foreign policy. Developing exchange and cooperation with Asian countries, economic integration with APR, the rapid export-oriented development of the Far Eastern Federal District have been among the priorities in Russia's policy agenda for the last few years[19] (and especially after the crisis in relations with the Western countries). Vast opportunities to produce water-

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[14] No.1 Central Document targets rural reform
Retrieved from http://news.xinhuanet.com/english/china/2014-01/19/c_133057121.htm

[15] ASEAN Integrated Food Security Framework; Strategic Plan Of Action On Food Security in the ASEAN Region Retrieved from:
http://www.gafspfund.org/sites/gafspfund.org/files/Documents/Cambodia_11_of_16_REGIONAL_STRATEGY_ASEAN_Integrated_Food_Security_Framework.pdf

[16] A level of 50% means that at least half of products, consumed in Japan is local www.maff.go.jp/e/pdf/basic_plan.pdf

[17] GRAIN briefing 2008. Seized! GRAIN Briefing Annex. The 2008 land grabbers for food and financial security; Squeezing Africa Dry: Behind every land grab is a water grab. GRAIN Report, 2012.

[18] Danilov-Danilyan, V. I. (2005). Freshwater deficiency and the world market. *Water resources*, 32(5), 572-579.

[19] Makarov I. et al. (2014) Towards the Great Ocean – 2, or Russia's Breakthrough to Asia. Moscow, *Valdai Discussion Club.*

intensive products represent one of the most appropriate foundations for the integration of Russia into APR.

Russia and APR represent a good case to check the main hypothesis of this study. In this case, we avoid the hegemony issue as neither Russia nor China can be defined as a regional water hegemony[20]. We investigate the region where water stress represents one of the biggest challenges for development. We deal with the region which disposes the biggest world reserves for a considerable increase of agricultural and industrial production—Siberia[21].

3. **Literature review**

Water and food security remain a core component of national security, putting global and regional water related problems into the area of the international political economy. A wider treatment of the virtual water concept is a Keohane and Nye's theory of complex interdependence introduced in 1970s[22]. Initially the theory focused mostly on financial and economic interdependence (in terms of FDI, trade, transnational business) but rising pressure on natural resources, especially water, and environmental failures in a number of international basins expanded its focus to environmental interdependence as well[23]. According to the theory, military force and coercion become less efficient in international relations while mutual interest becomes more powerful in the decision-making process, including that related to water issues.

Attempts to analyse international trade through a water prism (and major trajectories of virtual water flows) have been regularly made since 1990s. A considerable impulse for this kind of research was drawn from studies on national water footprints conducted by Hoekstra and Chapagain. In this paper, we use the conventional definition of the water footprint of a product as the volume of fresh water appropriated to produce the product, taking into account the volumes of water consumed and polluted in the different steps of the supply chain.

Hoekstra and Chapagain managed to estimate water footprints for all the countries[24]. Then, using crop trade statistics, they completed an intraregional virtual water database[25]. Their research revealed that the biggest virtual water exporters are water abundant Latin and Northern America, South-East Asia and Australia (due to high per capita water abundance) while importers are

[20] One of key challenges mentioned within water sustainability debates is lack of sub-national governance in this area. According to R.Keohane and J.Nye (Keohane, R.O., & Nye, J.S. (1987). Power and Interdependence Revisited. International Organization, 41(4)), any maintenance of the structure needs a leader/hegemon. Thus, a leader has to be interested in this maintenance, i.e. allocation of short-run gains between involved participants. While China is an upstream hegemon towards all its neighbors and thus completely controls water on its territory and also can control water flowing outside, China has all gains and has no intention to reallocate them. This explains the absence of developed basin regimes in the whole South-East Asia and also conserves this approach as a best-practice for all other upstreamers towards their less lucky downstream riparians. Meanwhile regime is an important tool for Pareto-improvements but even without regimes some optimization instruments are applied by states, e.g. by agricultural trade. For example, agreement of free food trade preceded free trade zone between China and ASEAN countries in 2011.

[21] Hereinafter we use term 'Siberia' according to its historical meaning – Russian territories Eastern to Ural mountains, including the Russian Far East which is a separate region in administrative term.

[22] Keohane, R. O., & Nye, J. S. (1977). *Power and interdependence: World politics in transition* (2nd ed., pp. 27-29). Boston: Little, Brown.

[23] Perrings, C. (2005). *Economy and environment: a theoretical essay on the interdependence of economic and environmental systems*. Cambridge University Press.

[24] Chapagain, A.K., Hoekstra, A.Y. (2004). Water footprints of nations. UNESCO-IHE: Value of Water Research Report Series No. 16.

[25] Hoekstra A.Y., Hung P.Q. (2002). Virtual water trade: a quantification of virtual water flows between nations in relation to international crop trade. UNESCO-IHE: Value of Water Research Report Series No. 11.

South and East Asia and Northern Africa[26]. In Western Europe net export of virtual water is allocated unevenly and declines (with a shift from positive to negative numbers) from the North to the South.

According to a study by International Water Management Institute, the virtual water trade already provides significant water savings on a global scale—for crops they reach 6%[27]. Hoekstra’s estimates are similar—the total water economy of the virtual water trade is around 5%[28].

At the same time the numerous attempts to find a strict relation between a country’s water abundance and its virtual water exports have not been successful. Wichelns [29]; Kumar and Singh[30]; Fraiture et al.[31]; and Lopez-Gunn and Llamas[32] showed that some factors such as arable land abundance, the institutional and business environment influence the foreign trade specialization of a state more than water abundance. Non-economic factors matter as well. Even the history of the virtual water concept itself underlines its non-economic dimension: it was introduced initially as a political tool to mitigate the Arab-Israeli conflict[33].

Regional estimates of the significance of water factor in the virtual water trade were provided for South Africa[34], Uzbekistan[35], Spain[36], Andalusia[37], India[38], and China[39]. In no regions did the authors find an intense virtual water trade flow from water-rich to water-poor areas, though in some cases economic specialization with a nod to the water factor was stated by the authors as a recommendation. However there was no research focused on trade in virtual water in Asia or APR as a whole or in Russia.

Evidence showing that the influence of water abundance on the international virtual water trade is limited. This leads to wide criticism of the virtual trade concept itself. For instance Merrett argues that virtual water trade does not exist in the sense that states who trade water-intensive goods usually do not pay any attention to their water footprint and ignore any correspondent water-saving potential[40].

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[26] Ibid.

[27] De Fraiture, C., Cai, X., Amarasinghe, U., Rosegrant, M., & Molden, D. (2004). *Does international cereal trade save water?The impact of virtual water trade on global water use* (Vol. 4). IWMI.

[28] Hoekstra, A. Y., & Hung, P. Q. (2002). Virtual water trade. *A quantification of virtual water flows between nations in relation to international crop trade. Value of water research report series*, *11*, 166.

[29] Wichelns, D. (2004). The policy relevance of virtual water can be enhanced by considering comparative advantages. *Agricultural Water Management*, 66(1), 49-63.

[30] Kumar, M.D., & Singh, O.P. (2005). Virtual water in global food and water policy making: is there a need for rethinking? *Water Resources Management*, 19(6), 759-789.

[31] De Fraiture C. et al. Op. cit.

[32] Lopez-Gunn, E., & Ramón Llamas, M. (2008). Re-thinking water scarcity: Can science and technology solve the global water crisis? *Natural Resources Forum*, 32(3), pp. 228-238.

[33] Allan, J. A. (2002). *The Middle East water question: Hydropolitics and the global economy* (Vol. 2). Ib Tauris.

[34] Earle, A. (2001). The role of virtual water in food security in Southern Africa. *Occasional Paper*, 33.

[35] Bekchanov, M., Bhaduri, A., Lenzen, M., & Lamers, J. (2012). *The role of virtual water for sustainable economic restructuring: evidence from Uzbekistan, Central Asia* (No. 167). ZEF Discussion Papers on Development Policy.

[36] Garrido A., Novo P., Rodríguez Casado R., Varela-Ortega C. (2009). Can virtual water ‘trade’ reduce water scarcity in semi-arid countries? The case of Spain. Paper presented at the International Association of Agricultural Economists Conference, Beijing, China.

[37] Velázquez, E. (2007). Water trade in Andalusia. Virtual water: An alternative way to manage water use. *Ecological Economics*, 63(1), 201-208.

[38] Verma S., Kampman D.A., van der Zaag P., Hoekstra A.Y. (2008). Going against the flow: A critical analysis of virtual water trade in the context of India's National River Linking Programme. UNESCO-IHE: Value of Water Research Report Series No. 31.

[39] Ma, J., Hoekstra, A. Y., Wang, H., Chapagain, A. K., & Wang, D. (2006). Virtual versus real water transfers within China. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 361(1469), 835-842.

[40] Merett, S. (2003). Virtual water and Occam's Razor. Water International, 28(1), 103-105.

Presently the only regions where water stress affects countries' trade specialization is in the Middle East and Northern Africa, where states increase imports of food (including from Russia) and contract local agricultural production because of rising water stress[41].

Since the early 1990s when the virtual water concept was introduced, many attempts to check its applicability to real-world processes have been made. Results remain mostly very modest. The weakest part of these studies is their static approach. Only one study applying dynamic analysis was performed by Young et al (2003)[42] and its outcomes were remarkable. After reaching some level of water deficit[43], a country starts to increase its demand for virtual water imports exponentially. This allows a prediction that given the rising water scarcity in many countries the role of water as a factor in international trade specialization will progressively increase. So will the volumes of trade in virtual water.

4. Research framework

This paper is the first attempt to provide quantitative estimates of virtual water trade flows within the APR with a particular focus on Russia. For our sample we chose nine countries of the region with the biggest GDP (including India which is not formally an APR country but is intensively involved in intraregional political and economic affairs): China, India, Indonesia, Japan, Korea Republic, Malaysia, Philippines, Russia and Thailand. While Russia, China, Indonesia and India are in top 10 (see Table A1) of the most water abundant countries in the world in absolute terms, levels of water stress and their water footprints significantly vary. High rates of population growth in China, India and Indonesia cause a rise in demand for water, while Japan and Korea face typical water challenges of developed countries with scarce water and land resources. Malaysia and Thailand combine intense water use in the agricultural and industrial sectors which increases water stress. There is no unified recipe for the region to cope with water stress but intraregional virtual water trade flows could play strategic role in ensuring regional water security.

We have applied the method of international virtual water trade flows estimation, from Hoekstra et al (2011[44], 2012[45]). It is based on the water footprints of different goods.

We also use the footprint classification[46]:

— *Blue footprint* is the volume of surface and groundwater consumed as a result of the production of a good or a service. Consumption refers to the volume of fresh water used and then evaporated or incorporated into a product. It also includes water extracted from surface or groundwater in a catchment and returned to another catchment or the sea. It is

[41] Allan, J.A. (2002). *The Middle East water question: Hydropolitics and the global economy* (Vol. 2). Ib Tauris; Yang, H., & Zehnder, A.J. (2002). Water scarcity and food import: a case study for southern Mediterranean countries. *World development*, 30(8), 1413-1430; Yang, H., Wang, L., & Zehnder, A. J. (2007). Water scarcity and food trade in the Southern and Eastern Mediterranean countries. *Food Policy*, 32(5), 585-605; El-Hamid F.A., Sami M., & Youssef T. (2008). Evaluation of Economical Aspects of Virtual Water in MENA Region. *In The 3rd International Conference on Water Resources and Arid Environment*, Riyadh, Saudi Arabia.

[42] Yang, H., Reichert, P., Abbaspour, K.C., & Zehnder, A.J. (2003). A water resources threshold and its implications for food security. *Environmental science & technology*, 37(14), 3048-3054.

[43] normally counted as an annual water resources per capita: in early 1980s it was around 2000 m3/person, in late 1990s it sinks to 1500 m3/person

[44] Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M., & Mekonnen, M.M. (2011). The Water Footprint Assessment Manual– Setting the Global Standard, Earthscan. *London, UK*.

[45] Hoekstra, A.Y., & Mekonnen, M.M. (2012). The water footprint of humanity. *Proceedings of the National Academy of Sciences*, 109(9), 3232-3237.

[46] http://www.waterfootprint.org/?page=files/Glossary

the amount of water extracted from groundwater or surface water that does not return to the catchment from which it was withdrawn.

- *Green footprint* is the volume of rainwater consumed during the production process. This is particularly relevant for agricultural and forestry products, where it refers to the total rainwater evapotranspiration from fields and plantations, plus the water incorporated into the harvested crop or wood.
- *Grey footprint* is an indicator of fresh water pollution that can be associated with the production of a product over its full supply chain. It is defined as the volume of fresh water that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards. It is calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards.

We divide all traded goods into three groups: 1) crops and derived crop products; 2) derived animal products; 3) industrial goods.

For crops and derived crop and animal products we multiply the volume of trade in each commodity to its average water footprint per ton of product in the exporting country. Their water footprints by country are provided by Mekonnen and Hoekstra (2010a) (crop and derived crop goods) and Mekonnen and Hoekstra (2010b) (derived animal goods)[47]. Data on exports and imports were taken from FAOSTAT Database.

The water footprint and water withdrawal data are usually hard to collect on a regular basis in all countries for all produced goods. In the case of the absence of any data on the water footprint for some product groups in any country we used an assumption that world average for this group might be applied. The water footprint of some final derived crop and animal products if there was no relevant data, was assumed to be equal to water footprint of the underlying primary good. Finally, if we discovered a lack of water footprint data for any particular good we have excluded it from the analysis.

As there are no data on individual industrial commodities we use generalized data for the whole sector. Hence, we multiply the water footprint per dollar of industrial output in the exporting country to the value of its industrial exports. Water footprints for national industrial sectors were calculated by Mekonnen and Hoekstra (2011)[48]. Table 1 represents the relevant data. Data on exports and imports of industrial goods was taken from UN COMTRADE database.

[47] Mekonnen, M.M, Hoekstra, A.Y. (2010). The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47 (UNESCO-IHE, Delft, The Netherlands).Volume II. Mekonnen, M.M, Hoekstra, A.Y. (2010). The green, blue and grey water footprint of farm animals and derived animal products, Value of Water Research Report Series No. 48 (UNESCO-IHE, Delft, The Netherlands). Volume II.

[48] Mekonnen, M.M, Hoekstra, A.Y. (2011). 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.

Table 1 – Average water footprint per unit value added (m^3/1000 US $), 1996-2005

Country	Average water footprint per unit value added (m^3/1000 US $)		
	Blue	**Grey**	**Total**
China	9,8	126,0	135,8
India	13,3	252,7	266,0
Indonesia	0,3	5,6	5,9
Japan	0,6	3,6	4,2
Korea Republic	0,8	3,1	3,9
Malaysia	2,0	38,5	40,5
Philippines	14,7	280,2	295,0
Russia	15,2	289,1	304,3
Thailand	2,3	44,5	46,8
Global average	**4,0**	**38,9**	**43,0**

The limitations mentioned above do not allow us to present our results as the precise amounts of virtual water trade, only rough estimates. Meanwhile these estimates are compatible and representative, providing some interesting and illustrative outcomes.

For this study we need a continued time series. All the water footprint databases provide data for only 1996-2005 period, but the intense rise of APR (both politically and economically) which changed the picture of the region has been continuing. The water footprint of most of products is very stable and changes very slowly so we assumed that it remained constant. Mekonnen and Hoekstra use the same assumption, at least in their online database (waterfooootprint.org) they continue to use indicators of the 1996-2005 period for the analysis of trade flows which took place later.

5. Results

Table 1 provides evidence that Russia's industry is much more water intensive than the industries of other Asian countries. For agricultural water use, the water footprint for particular derived animal, crop or derived crop products is presented in table B1 (Appendix B): there are nine products and Russia ranks first by water intensity in regard to 4 of them and ranks second in 3.

From the perspective of water economy on a global scale the export of water-intensive goods from APR to Russia is beneficial as it allows Russia to save the fraction of water which would be used for production in Russia but is not required to produce the same products in APR states. However what is rational from the global perspective can have negative regional implications. If imports of industrial goods from China or other APR states increase, it will have a negative impact on APR environmental and water security. Apparently the immediate economy in water would not contribute to the sustainable development of the region. Thus, regional water security contradicts global security. From the regional perspective, exporting virtual water from Russia to APR is much more appropriate as it allows water resources to be saved in countries where they are scarce though this would increase global water consumption.

Table C1 (Appendix C) represents the water footprint of exports of crops, derived crop and animal products for 1996-2005 between the countries sampled. Hereinafter the left column represents the exporter, and upper rows, the importers. The leaders among virtual water exporters are the South-East Asian countries: Malaysia, Indonesia and Thailand. Various factors explain this phenomenon. The specialization in agricultural exports (especially water-intensive crops like rice), close economic ties with the main East Asian consuming countries (China, Japan, Korea) and a humid climate explain the large green footprint. The very low virtual water flows from Korea and Japan are also not surprising. These two countries have limited agricultural sectors and import crops and animal products. Exports of derived crop and animal products are limited and not very water-intensive due to the high water efficiency and limited precipitation levels. The largest virtual water importers are China and India because of the large volume of total agricultural exports. Russia had nearly no agricultural exports to APR countries at the given period hence its virtual water exports was close to zero.

Table C2 shows estimates made in the same way for the period 2006-2010. The overall proportion of indicators for the countries remained similar, though the numbers themselves rose significantly due to the economic development of the given countries and the intensification of trade among them. Russia's exports of virtual water to APR also grew albeit remaining one of the lowest. The greatest change was in trade with India. Russia's exports of virtual water to this country have jumped in recent years. This was related to a large contract of crop supplies (the Russian company Agriko won a tender organized by the Indian state company STC[49]).

Tables C3 and C4 provide data on net exports of virtual water associated with industrial goods. The numbers in these tables are much less dispersed than in the case of agriculture-related virtual water trade. The main net exporter of water-intensive industrial products is China which is not surprising given the total amount of industrial exports by this country. Philippines' virtual water net exports significantly exceed the average, primarily because of the large volume of water pollution (the grey footprint) generated in producing industrial goods for export. The main net importer of water-intensive industrial goods is Japan.

Tables 2 and 3 present the total amount of virtual water trade in APR, summarising data from tables C1-C6. Tables 4 and 5 provide the same information in more illustrative way. They summarize data from Tables 2 and 3 and focus on net exports of virtual water.

Table 2 – Total virtual water trade among largest APR countries, mln cubic meters, 1996-2005

	Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines	**Total exports to 8 partners**
Russia		516,8	274,8	53,7	230,1	43,4	65,2	77,6	39,6	**1301,2**
China	1787,5		742,9	11020,9	7932,6	628,5	2212,2	2683,0	1198,8	**28206,5**
India	1439,2	2924,9		1829,2	1832,3	1266,7	2937,3	1545,1	979,2	**14753,9**
Japan	10,1	210,4	10,7		184,0	112,4	79,8	58,0	39,3	**704,9**
Korea	94,3	257,0	14,6	930,1		11,5	73,1	25,9	73,3	**1479,9**
Thailand	670,2	6578,0	331,7	7929,7	2594,2		4793,8	5896,1	1160,1	**29953,9**
Indonesia	481,2	3640,7	4233,3	5620,9	2836,3	308,2		3293,3	662,1	**21076,0**
Malaysia	777,7	9602,6	5596,4	2733,7	2363,4	648,5	972,7		537,3	**23232,4**
Philippines	17,3	745,0	31,9	2757,8	742,7	327,9	299,9	930,3		**5852,9**

[49] http://rbcdaily.ru/industry/562949979074317

Table 3 – Total virtual water trade among largest APR countries, mln cubic meters, 2006-2010

	Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines	Total exports to 8 partners
Russia		411,5	2644,1	210,4	326,2	201,9	296,3	68,9	158,6	**4317,8**
China	4614,6		4094,6	18879,3	12531,8	2563,1	3180,7	3728,4	2090,7	**51683,3**
India	870,4	18037,5		3476,4	2796,6	2646,6	4449,8	4118,0	671,8	**37067,1**
Japan	46,5	507,7	26,7		310,7	157,2	54,7	68,6	50,8	**1222,9**
Korea	111,8	675,8	31,1	1020,4		22,3	72,1	59,8	61,6	**2055,0**
Thailand	499,5	13029,6	1070,0	7444,4	4206,6		4402,7	8034,0	2699,4	**41386,3**
Indonesia	1137,4	8992,0	13099,8	9514,8	3185,3	572,7		8771,3	1488,6	**46761,8**
Malaysia	1382,0	21684,2	3616,5	3623,2	2450,9	1418,6	1558,1		1493,0	**37226,7**
Philippines	35,0	1714,0	94,4	3301,6	1030,7	415,4	248,6	864,3		**7704,1**

Table 4 Net exports of virtual water, mln. cubic meters, 1996-2005

	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines
Malaysia								-392,9
Indonesia							2320,6	362,1
Thailand						4485,5	5247,6	832,2
Korea					-2582,7	-2763,2	-2389,3	-669,4
Japan				-746,2	-7817,3	-5541,1	-2675,6	-2718,5
India			1818,5	1817,7	935,0	-1296,0	-4051,2	947,3
China		-2182,0	10810,5	7675,6	-5949,5	-1428,5	1905,3	1181,6
Russia	-1270,7	-1164,4	43,6	135,8	-626,8	-403,5	-700,1	22,3

Table 5 Net exports of virtual water, mln. cubic meters, 2006-2010

	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines
Malaysia								628,7
Indonesia							7213,2	1240,0
Thailand						3830,0	6615,4	2284,0
Korea					-4184,4	-3113,2	-2510,8	-969,1
Japan				-709,7	-7287,2	-9460,1	-3554,6	-3250,9
India			3449,7	2765,5	1576,6	-8650,0	501,5	577,3
China		-13942,9	18371,6	11856,0	-10466,6	-5811,3	2346,4	2055,7
Russia	-4203,1	1773,7	163,9	214,4	-297,6	-1068,4	-1313,1	123,6

The main trends are similar to those shown earlier: virtual water flows follow from the humid countries of South-East Asia to the developed countries of North-East—Japan and Korea. South East Asian countries are the main guarantor of water security of APR at the moment. Another large exporter of virtual water is China, which primarily due to the huge volumes of its exports and its relatively low water-efficiency. Russia shows very modest numbers due to limited volumes of trade with other countries of the region. At the same time for the last ten years Russia's exports of virtual water to APR have grown due to a rising exports to India.

Russia used to have a positive virtual water trade balance with Japan and Korea (where the agricultural share of GDP and exports is small and water use is efficient). The positive balance with India is based on the export of wheat. The positive balance with the Philippines may be disregarded because of the very low amount. Russia's virtual water trade balances with China, Indonesia and Malaysia are negative as is the overall total of all the seven countries of the sample taken together. Our estimates show therefore that despite Russia's water abundance it acts as a net importer of virtual water from leading APR countries.

Tables 6 and 7 show the water-intensity of trade flows within APR, i.e. volume of water used per dollar of trade. The lowest water intensity is in exports from Japan and Korea, two developed high-tech producers. India and ASEAN states are leaders. The Russian figure is abnormally low. It relates to hydrocarbon dominance in the structure of Russian exports, and the high share of primary and uncultivated commodities.

Comparing the two tables, we can see that water intensity of exports has decreased in all countries besides Russia. For example, China cut by half the water intensity of its exports to Russia. Russia's exports to China also became less water-intensive but this is explained by the decrease of the share of agro-exports to China and the switch to hydrocarbons, rather than by improvements in water efficiency.

Table 6 Virtual water per dollar of exports, cubic meters per thousand dollars, 1996-2005

	Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines
Russia		81,1	242,1	20,4	189,2	246,0	818,9	322,1	339,2
China	407,4		193,9	231,2	518,3	499,6	638,8	636,4	534,7
India	1824,6	1512,6		993,6	2844,3	2086,0	4308,7	2262,9	3590,8
Japan	6,7	5,3	4,3		6,1	7,4	10,8	4,7	4,5
Korea	58,7	10,0	7,1	53,9		4,9	22,2	6,8	25,5
Thailand	4079,2	1710,6	586,2	764,9	1977,0		2660,7	1863,7	965,1
Indonesia	4818,8	1171,8	3215,4	425,9	690,6	249,1		1667,2	744,0
Malaysia	4153,8	2145,0	2668,8	248,1	768,2	161,3	532,9		375,6
Philippines	1280,7	565,4	490,5	513,7	761,2	320,6	1327,4	616,8	

Table 7 Virtual water per dollar of exports, cubic meters per thousand dollars, 2006-2010

	Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines
Russia		23,2	586,7	24,9	50,1	260,0	740,0	223,7	492,4
China	185,2		145,4	178,5	210,7	181,8	209,2	193,8	245,8
India	834,0	1633,1		981,3	2485,2	1490,2	1592,9	1548,6	981,5
Japan	5,1	4,3	3,9		5,7	5,9	5,0	4,6	5,3
Korea	16,0	7,6	3,8	38,9		4,4	10,8	11,0	13,0
Thailand	808,4	811,9	341,9	410,4	1337,8		831,9	944,9	798,5
Indonesia	3026,6	790,9	1994,1	405,0	353,0	166,3		1378,5	682,9
Malaysia	2120,2	1201,3	607,6	206,6	358,9	155,2	300,0		587,1
Philippines	1113,5	349,7	404,2	446,4	525,9	286,3	535,0	439,1	

Here we see a paradox: while other countries are forced to save their fresh water, Russia does not make any water economies and at the same time does not increase exports of water-intensive goods to APR. Russia's potential for virtual water production and exports is therefore underused.

6. **Discussion**

Calculations reveal that the factors undermining water security in APR (and thus national and regional security as a whole) are strengthening because of the rising demand for water-intensive goods in the region from both water stressed and water-abundant countries. Meanwhile, the increased attention of Asian countries to water efficiency issues may be considered a good sign (see tables 6 and 7).

The resulting estimates of virtual water trade flows within APR prove our initial hypothesis. APR countries with rising water stress increased their exports to Russia, a water abundant country, which provides short-term gains in water economy (as Russia's production is less water-efficient than the production in other APR counties) but conserves the long-term inefficiency of the allocation of water-intensive industries in the region. In accordance with the virtual water concept, the reallocation of water-intensive industries from APR counties to Russia would be a better solution to decrease the regional water deficit.

This conclusion has promising implications for the strategy for the development of Russian Eastern territories. Siberia and the Russian Far East have vast opportunities to get involved in APR intraregional affairs, especially as a key virtual water exporter. Besides statistics, there is also a strategic argument—there is no evidence that water stress in the region will decrease even over the long-term. At the moment, Russia has only a small amount of virtual water exports (4.2 bln. cubic meters). Compared with Canada (a country with similar hydrological and climate conditions), where net virtual water exports are 52.5 bn cubic meters[50].

The second argument is related to the significant potential for agricultural production in Siberia and the Far East: there are both reserves of arable lands (more than 10 mln ha may be additionally involved in agriculture) and the potential for crop productivity to increase more than 250%)[51]. Despite high positions in the world rankings of crops exporters, Russia still underuses its agricultural potential, notably in the Eastern part of the country. The south of Siberia and the Far East are water-abundant territories with vast non-cultivated arable lands. However a small labour force, poor infrastructure and the lack of political will have remained major impediments to the development of local agriculture. Institutional factors and underdeveloped infrastructure have limited the supplies of Russian agricultural products for decades. But nowadays Russia has a chance to overcome these obstacles as large export opportunities have recently appeared due to the rise of the biggest product import market near the Eastern borders of Russia: China's economic growth during the last decade has decelerated from double figures to 7-8% but China still demonstrates rapid growth in consumption and therefore the rising demand for water—both physical and virtual. In addition, the limited capability to satisfy this demand from internal and even previously used external sources is apparent.

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[50] Mekonnen, M.M., Hoekstra, A.Y. (2011). 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).Volume II Appendices.
[51] Likhacheva, A., Makarov, I., Savelyeva, A. (2010). Daily Bread and Water. *Russia in Foreign Affairs*. 8(4).

With a reasonable foreign and internal economic policy Russia may become in the medium term a key guarantor of water and food security in the Asian region, avoiding narrow energy specialization. This opportunity has been neglected by Russian decision makers and the expert community for years and has never been included in the international agenda (which is logically explained by the hydro-hegemony theory: the current hegemony, the ABCD[52], which controls the majority of the virtual water trade, is not interested in a new independent player[53]).

In recent years, the virtual water debate has increased little by little[54]. A positive result is an important paragraph in Russian Water Strategy 2020, for the first time the following goal appeared in State strategy document: 'to study opportunities to unlock the agricultural and water potential of the Russian Federation, to investigate the conditions to use these competitive advantages, to analyse water-intensive production allocation, identify forms of participation of Russia in the formation of a global water market'[55].

Currently a general framework for the development of the Russian Far East is being elaborated by the Ministry of Far Eastern Development. This framework suggests the establishment of 'advanced special economic zones' (or 'territories of rapid development') along with state support for some key private projects. Allocation and specialization of advanced special economic zones and investment projects is now being discussed in government[56]. We suggest that at least some of them should be aimed at the production of water-intensive goods: food, processed mineral resources, chemicals which correspond to Russia's comparative advantages.

To promote virtual water exports from Russia, some regional organizations can be used: Russia put food security forward as a topic for the Russia-ASEAN Summit in 2013, this question arose again during the Shanghai Cooperation Organization (SCO) Summit in Dushanbe in September 2014 and can be developed further with Russia's chairmanship of SCO for 2014-2015. Some possible formats for developing intraregional trade in water-intensive industries are also BRICS (under Russian chairmanship in 2015), APEC and the East-Asian Summit (EAS).

Russia's integration into APR's virtual water market would provide considerable benefits. But more importantly, according to the interdependence theory, Russia, acting as a guarantor of Asia's food and water security, would provide long-term positive effects for the whole region through diminishing water stress and desecuritization of food trade and water allocation in South and East Asia.

As for paradox about long-term positive effect of short-run decrease in regional (and global) water savings through virtual water trade, we suppose it makes some contribution to the virtual

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52 ABCD means 4 agro-conglomerates: Archer Daniels Midland, Bunge, Cargill and Louis Dreyfus, which control around 70-90% of traded agro-products. See Lawrence, F. (2011). The global food crisis: ABCD of food – how the multinationals dominate trade. Wherever you live, you can't avoid the four global giants [online]. *The Guardian*, 2 June. Available at: http://www.guardian.co.uk/global-development/poverty- matters/2011/jun/02/abcd-food-giants-dominate-trade.

53 At the same time, Agro Big-4 already controls up to one third of Russian agro-market.
Koltunova, O. (2008). Zernoviy put. *Kompania*, №13 (506), 07.04.2008

54 Danilov-Danil'yan, V.I. (2009). Water resources: A strategic factor in the long-term development of the Russian economy. *Herald of the Russian Academy of Sciences*, 79(5), 420-428. Barabanov, O.N., Bordachev, T.V. (2012). Towards the Great Ocean, or the New Globalization of Russia. Moscow, *Valdai Discussion Club*; Karaganov S.A. (ed.)(2014) Toward the Great Ocean–2, or Russia's Breakthrough to Asia, Moscow, *Valdai Discussion Club*; Likhacheva, A., Makarov, I., Savelyeva, A. (2010). Daily Bread and Water. Russia in Foreign Affairs. 8(4), P.80-93. Makarov I. et al. (2014) Towards the Great Ocean -2, or Russia's Breakthrough to Asia. Moscow, *Valdai Discussion Club*.

55 Federal Water Resources Agency, Ministry of Natural Resources and Environment of the Russian Federation (2009) Water Strategy of Russian Federation to 2020. Retrieved Jan.30, 2014 from http://www.mnr.gov.ru/regulatory/detail.php?ID=128717

56 Project of introduction of amendment to a Federal special program on the development of Far East and Zabailye regions. Available at: http://minvostokrazvitia.ru/upload/iblock/88d/Doc10-1.pdf

water concept and may be further developed and checked in other similar case-studies (Brazil and Canada are promising cases). Moreover, the traditional dimension of interdependence as an economic issue is evolving more and more into resource issue, particularly environmental interdependence. As for Russia in this case study, we hope that this paper will enrich the discussion and contribute to new research in the region including more variables and new data.

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Appendix A

Table A1. Annual amount of renewable water resources, average 2000-2011, cubic km per year

Country	km^3/year	GDP, 2011, $ bln[57]	Population, 2011, mln.
Brazil	8233	2 289	197
Russia	**4498**	**3 134**	**143**
Canada	3300	1 394	34
USA	3069	14 991	312
Indonesia	2838	1 123	242
China	2739	11 291	1 344
Columbia	2132	471	47
Peru	1913	301	29
India	1908	4 532	1 241
DRK	1283	25	68

Worldwater.org, databank.worldbank.org

Table A2 Structure of water use for top-10 water withdrawers, average 2000-2011

Country	Withdrawal km^3/year	Share of renewable water resources, %	Withdrawal m^3/person/year	Domestic,%	Industry,%	Agro %	$ GDP/ m3
India	661	45,7	575	7	2	91	1,2
China	545	19,4	417	10	21	69	4,5
USA	477	16,9	1 605	13	46	41	23,5
Pakistan	176	72,0	1 099	4	2	94	0,6
Iran	92	71,7	1 313	6	1	93	1,4
Japan	90	20,9	706	19	18	63	55,7
Indonesia	113	5,6	496	12	7	82	2,1
Mexico	77	18,9	719	14	9	77	8,6
Philippines	80	16,7	931	8	10	83	1,5
Russia	**66**	**1,5**	**461**	**20**	**60**	**20**	**5,7**

Worldwater.org, databank.worldbank.org, FAO AQUASTAT

[57] GDP (PPP) in current dollars

Appendix B

Table B1 Water intensity of particular goods and products

	China	India	Indonesia	Japan	Korea, Republic of	Malaysia	Philippines	Thailand	Russia
Pork	5 440	5 834	5 364	4 947	5 317	4 344	5 801	*6 451*	**7 474***
Poultry	2 212	5 246	3 926	1 660	2 834	3 282	*4 415*	3 834	**4 708**
Milk and cream	1 433	1 369	**3 011**	1 256	1 466	1 772	1 799	1 609	*1 968*
Butter	5 044	4 819	**10 597**	4 421	5 160	6 237	6 332	5 663	*6 927*
Wheat	821	634		1 078	1 392			**4 174**	*2 298*
Barley	556	1 246		493	536			*2 048*	**2 205**
Maize	791	2 239	1 368	1 506	1 294	**2 363**	1 986	919	1 022
Rye	1 852				1 962				**2 167**
Potatoes	215	221	277	109	130		369	**381**	298

*In bolds – first rank, in italics – second rank. Blank box – no data available

Appendix C

Table C1 –Water footprint of exports of crops, crops derived and animal products, mln cubic meters, 1996-2005

		Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines
Russia	Green		91,0	23,9	8,3	104,8	0,7	46,3	8,3	5,2
	Blue		0,6	0,5	0,2	1,5	0,0	0,6	0,1	0,0
	Grey		2,5	2,0	0,5	4,0	0,0	1,8	0,3	0,1
	Total		**94,2**	**26,4**	**9,0**	**110,3**	**0,8**	**48,7**	**8,7**	**5,3**
China	Green	950,6		252,6	4348,1	4384,3	362,9	1232,4	1528,9	606,9
	Blue	97,6		7,5	328,1	483,1	24,4	210,9	138,2	145,6
	Grey	212,7		75,2	1125,8	1511,7	91,4	423,0	522,8	200,9
	Total	**1260,9**		**335,4**	**5801,9**	**6379,1**	**478,7**	**1866,3**	**2190,0**	**953,4**
India	Green	1035,8	2216,0		1473,8	1399,8	1040,2	2222,2	1034,0	586,6
	Blue	186,9	345,6		138,1	236,6	107,7	441,3	293,9	265,4
	Grey	86,7	161,6		73,2	92,8	52,2	182,4	113,1	89,8
	Total	**1309,4**	**2723,3**		**1685,1**	**1729,2**	**1200,1**	**2845,9**	**1441,0**	**941,7**
Japan	Green	3,0	55,6	1,1		60,8	44,9	37,0	9,4	5,2
	Blue	0,0	2,0	0,0		1,9	3,1	9,6	0,5	0,1
	Grey	1,0	3,1	0,1		6,8	5,7	4,5	1,2	0,4
	Total	**4,1**	**60,7**	**1,2**		**69,6**	**53,7**	**51,0**	**11,1**	**5,7**
Korea	Green	66,6	125,6	5,6	693,2		2,5	43,6	8,8	41,6
	Blue	6,6	33,3	1,2	24,6		0,4	14,8	2,3	17,9
	Grey	15,7	9,1	0,5	162,5		0,4	3,6	0,7	3,7
	Total	**88,8**	**167,9**	**7,3**	**880,3**		**3,2**	**62,0**	**11,8**	**63,2**
Thailand	Green	541,1	5531,3	265,7	6482,5	2178,5		3854,2	4930,5	933,4
	Blue	103,0	647,3	28,3	750,2	268,9		717,6	601,2	135,0
	Grey	21,9	289,2	17,6	359,1	109,8		169,3	257,1	46,1
	Total	**666,1**	**6467,8**	**311,6**	**7591,8**	**2557,2**		**4741,1**	**5788,8**	**1114,5**
Indonesia	Green	460,2	3490,4	4045,2	5406,6	2630,6	282,4		3127,4	612,4
	Blue	4,5	11,3	5,5	27,3	82,3	2,9		17,4	11,6
	Grey	16,2	132,5	181,2	163,7	118,9	19,0		141,6	35,5
	Total	**480,9**	**3634,2**	**4231,9**	**5597,5**	**2831,8**	**304,3**		**3286,4**	**659,5**
Malaysia	Green	738,4	9172,1	5344,4	2355,6	2236,1	492,7	809,8		465,1
	Blue	7,8	7,3	6,7	3,9	1,9	18,6	76,7		11,1
	Grey	27,0	305,9	217,1	83,1	61,7	24,2	39,6		17,9
	Total	**773,1**	**9485,3**	**5568,2**	**2442,6**	**2299,8**	**535,5**	**926,1**		**494,2**
Philippines	Green	14,0	424,8	14,4	1350,8	510,6	44,4	241,5	499,3	
	Blue	0,1	0,5	0,0	2,9	4,0	1,8	4,1	1,8	
	Grey	0,6	11,0	0,3	43,8	10,1	4,3	5,9	10,8	
	Total	**14,7**	**436,2**	**14,8**	**1397,5**	**524,7**	**50,5**	**251,5**	**511,9**	

Table C2 –Water footprint of exports of crops, crops derived and animal products, mln cubic meters), 2006-2010

		Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines
Russia	Green		31,3	1664,8	82,9	79,8	68,8	206,1	11,8	95,5
	Blue		0,5	20,7	1,6	0,9	0,9	2,7	0,1	1,2
	Grey		1,0	60,9	2,6	2,7	2,7	7,8	0,7	3,6
	Total		**32,7**	**1746,3**	**87,1**	**83,4**	**72,4**	**216,7**	**12,6**	**100,4**
China	Green	1060,9		371,2	4858,7	3859,3	618,7	1030,4	987,7	743,2
	Blue	60,3		8,3	395,7	667,2	41,3	115,4	60,9	125,8
	Grey	334,1		103,4	1166,9	1126,4	192,3	329,3	301,4	208,8
	Total	**1455,3**		**482,9**	**6421,3**	**5652,9**	**852,3**	**1475,1**	**1350,0**	**1077,8**
India	Green	537,1	12549,1		2940,4	2112,2	1998,2	3320,9	3091,9	491,9
	Blue	87,0	3314,6		124,4	262,8	284,6	504,5	389,3	34,2
	Grey	43,4	1510,8		119,1	122,3	138,0	266,4	286,1	29,7
	Total	**667,5**	**17374,5**		**3183,8**	**2497,2**	**2420,8**	**4091,9**	**3767,3**	**555,8**
Japan	Green	8,0	82,4	1,0		98,3	47,9	12,1	12,9	14,5
	Blue	0,1	3,3	0,0		3,2	2,5	0,4	0,5	0,2
	Grey	1,1	5,0	0,1		10,5	5,2	1,2	2,2	0,6
	Total	**9,3**	**90,7**	**1,1**		**112,0**	**55,6**	**13,7**	**15,6**	**15,3**
Korea	Green	63,9	273,5	3,0	748,1		3,8	41,8	38,5	31,3
	Blue	3,8	72,0	0,2	31,4		0,9	11,2	1,4	12,5
	Grey	18,0	21,5	0,2	163,4		0,4	2,8	0,5	3,1
	Total	**85,8**	**367,0**	**3,3**	**942,9**		**5,2**	**55,8**	**40,4**	**46,9**
Thailand	Green	386,6	10897,5	824,5	5829,4	3805,0		3467,3	6694,0	2241,1
	Blue	67,1	1015,4	87,0	682,4	216,1		562,9	692,7	259,8
	Grey	26,0	599,0	44,8	322,9	95,2		172,8	369,4	79,6
	Total	**479,8**	**12511,8**	**956,3**	**6834,7**	**4116,3**		**4203,0**	**7756,1**	**2580,4**
Indonesia	Green	1084,3	8549,8	12592,4	9192,1	2966,7	524,3		8394,3	1390,6
	Blue	12,3	6,0	39,3	28,9	81,4	7,4		20,8	21,3
	Grey	39,9	422,9	463,2	261,8	128,9	30,4		342,0	70,5
	Total	**1136,5**	**8978,8**	**13094,9**	**9482,8**	**3177,0**	**562,1**		**8757,1**	**1482,5**
Malaysia	Green	1307,3	20494,4	3377,2	3152,7	2268,9	1083,6	1272,0		1361,4
	Blue	9,5	18,3	6,7	4,4	8,8	27,0	97,1		21,3
	Grey	50,5	699,0	137,3	112,3	70,4	43,8	66,0		51,2
	Total	**1367,3**	**21211,7**	**3521,3**	**3269,3**	**2348,1**	**1154,5**	**1435,2**		**1433,8**
Philippines	Green	29,5	560,7	33,3	1507,0	648,2	107,6	133,0	381,0	
	Blue	0,0	0,5	0,2	5,3	2,2	6,8	7,6	3,3	
	Grey	0,9	13,0	0,7	47,2	16,2	12,8	8,1	14,1	
	Total	**30,4**	**574,2**	**34,1**	**1559,5**	**666,5**	**127,3**	**148,7**	**398,5**	

Table C3 –Water footprint of exports of industrial goods, mln cubic meters, 1996-2005

		Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines
Russia	Green		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Blue		21,1	12,4	2,2	6,0	2,1	0,8	3,4	1,7
	Grey		401,5	236,0	42,5	113,8	40,5	15,7	65,5	32,6
	Total		**422,7**	**248,4**	**44,7**	**119,8**	**42,6**	**16,5**	**69,0**	**34,3**
China	Green	0,0		0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Blue	38,1		29,5	377,5	112,4	10,8	25,0	35,7	17,8
	Grey	488,5		378,1	4841,5	1441,2	139,0	320,9	457,4	227,7
	Total	**526,6**		**407,6**	**5219,0**	**1553,5**	**149,8**	**345,9**	**493,0**	**245,4**
India	Green	0,0	0,0		0,0	0,0	0,0	0,0	0,0	0,0
	Blue	6,5	10,1		7,2	5,2	3,3	4,6	5,2	1,9
	Grey	123,3	191,6		136,9	97,9	63,3	86,8	98,9	35,6
	Total	**129,7**	**201,6**		**144,2**	**103,0**	**66,6**	**91,4**	**104,1**	**37,5**
Japan	Green	0,0	0,0	0,0		0,0	0,0	0,0	0,0	0,0
	Blue	0,8	20,6	1,3		15,7	8,1	4,0	6,5	4,6
	Grey	5,2	129,1	8,2		98,7	50,7	24,8	40,4	29,0
	Total	**6,1**	**149,7**	**9,5**		**114,4**	**58,8**	**28,7**	**46,9**	**33,7**
Korea	Green	0,0	0,0	0,0	0,0		0,0	0,0	0,0	0,0
	Blue	1,1	17,7	1,5	9,9		1,6	2,2	2,8	2,0
	Grey	4,4	71,4	5,8	39,9		6,6	8,9	11,3	8,1
	Total	**5,5**	**89,1**	**7,3**	**49,8**		**8,3**	**11,1**	**14,1**	**10,1**
Thailand	Green	0,0	0,0	0,0	0,0	0,0		0,0	0,0	0,0
	Blue	0,2	5,5	1,0	16,9	1,9		2,6	5,4	2,3
	Grey	3,9	104,8	19,1	321,1	35,2		50,0	102,0	43,3
	Total	**4,1**	**110,3**	**20,1**	**337,9**	**37,1**		**52,7**	**107,4**	**45,6**
Indonesia	Green	0,0	0,0	0,0	0,0	0,0	0,0		0,0	0,0
	Blue	0,0	0,3	0,1	1,2	0,2	0,2		0,4	0,1
	Grey	0,2	6,2	1,4	22,2	4,3	3,8		6,5	2,4
	Total	**0,3**	**6,6**	**1,5**	**23,4**	**4,5**	**4,0**		**6,9**	**2,5**
Malaysia	Green	0,0	0,0	0,0	0,0	0,0	0,0	0,0		0,0
	Blue	0,2	5,9	1,4	14,6	3,2	5,7	2,3		2,2
	Grey	4,3	111,5	26,7	276,6	60,4	107,4	44,2		41,0
	Total	**4,6**	**117,3**	**28,1**	**291,1**	**63,6**	**113,1**	**46,5**		**43,1**
Philippines	Green	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	
	Blue	0,1	15,4	0,9	68,0	10,9	13,9	2,4	20,9	
	Grey	2,5	293,4	16,3	1292,3	207,1	263,5	46,0	397,5	
	Total	**2,6**	**308,8**	**17,2**	**1360,3**	**218,0**	**277,4**	**48,5**	**418,4**	

Table C4 –Water footprint of exports of industrial goods, mln cubic meters, 2006-2010

		Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines
Russia	Green		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Blue		18,9	44,9	6,2	12,1	6,5	4,0	2,8	2,9
	Grey		359,9	852,9	117,1	230,6	123,0	75,6	53,6	55,3
	Total		**378,9**	**897,7**	**123,3**	**242,8**	**129,5**	**79,6**	**56,4**	**58,2**
China	Green	0,0		0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Blue	228,5		261,2	901,1	497,6	123,7	123,4	172,0	73,3
	Grey	2930,8		3350,4	11556,8	6381,4	1587,0	1582,3	2206,4	939,6
	Total	**3159,3**		**3611,7**	**12457,9**	**6879,0**	**1710,8**	**1705,6**	**2378,4**	**1012,9**
India	Green	0,0	0,0		0,0	0,0	0,0	0,0	0,0	0,0
	Blue	10,1	33,2		14,6	15,0	11,3	17,9	17,5	5,8
	Grey	192,8	629,9		277,9	284,4	214,5	340,0	333,2	110,2
	Total	**202,9**	**663,0**		**292,6**	**299,4**	**225,8**	**357,9**	**350,7**	**116,0**
Japan	Green	0,0	0,0	0,0		0,0	0,0	0,0	0,0	0,0
	Blue	5,1	57,4	3,5		27,3	14,0	5,6	7,3	4,9
	Grey	32,1	359,6	22,1		171,4	87,6	35,3	45,7	30,6
	Total	**37,3**	**416,9**	**25,6**		**198,7**	**101,6**	**40,9**	**53,0**	**35,4**
Korea	Green	0,0	0,0	0,0	0,0		0,0	0,0	0,0	0,0
	Blue	5,2	61,4	5,5	15,4		3,4	3,2	3,9	2,9
	Grey	20,9	247,4	22,3	62,1		13,7	13,1	15,6	11,8
	Total	**26,0**	**308,8**	**27,8**	**77,5**		**17,1**	**16,3**	**19,4**	**14,7**
Thailand	Green	0,0	0,0	0,0	0,0	0,0		0,0	0,0	0,0
	Blue	1,0	25,9	5,7	30,5	4,5		10,0	13,9	6,0
	Grey	18,7	491,9	107,9	579,2	85,8		189,7	264,1	113,1
	Total	**19,7**	**517,8**	**113,6**	**609,7**	**90,3**		**199,7**	**278,0**	**119,0**
Indonesia	Green	0,0	0,0	0,0	0,0	0,0	0,0		0,0	0,0
	Blue	0,0	0,7	0,2	1,6	0,4	0,5		0,7	0,3
	Grey	0,9	12,5	4,6	30,3	7,9	10,1		13,4	5,8
	Total	**0,9**	**13,2**	**4,9**	**31,9**	**8,3**	**10,6**		**14,1**	**6,1**
Malaysia	Green	0,0	0,0	0,0	0,0	0,0	0,0	0,0		0,0
	Blue	0,7	23,6	4,8	17,7	5,1	13,2	6,1		3,0
	Grey	14,0	448,9	90,5	336,2	97,7	251,0	116,8		56,3
	Total	**14,7**	**472,6**	**95,3**	**353,9**	**102,8**	**264,2**	**122,9**		**59,2**
Philippines	Green	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	
	Blue	0,2	57,0	3,0	87,1	18,2	14,4	5,0	23,3	
	Grey	4,4	1082,8	57,3	1655,0	346,0	273,8	94,9	442,6	
	Total	**4,6**	**1139,8**	**60,3**	**1742,2**	**364,2**	**288,2**	**99,9**	**465,8**	

Table C5 – Total virtual water trade among largest APR countries, mln cubic meters, 1996-2005

		Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines	Total exports to 8 partners
Russia	Green		91,0	23,9	8,3	104,8	0,7	46,3	8,3	5,2	**288,4**
	Blue		21,7	12,9	2,5	7,5	2,2	1,4	3,6	1,7	**53,5**
	Grey		404,0	238,0	43,0	117,8	40,5	17,5	65,8	32,7	**959,3**
	Total		**516,8**	**274,8**	**53,7**	**230,1**	**43,4**	**65,2**	**77,6**	**39,6**	**1301,2**
China	Green	950,6		252,6	4348,1	4384,3	362,9	1232,4	1528,9	606,9	**13666,7**
	Blue	135,7		37,0	705,6	595,5	35,2	235,9	173,9	163,3	**2082,1**
	Grey	701,2		453,3	5967,3	2952,8	230,4	743,9	980,2	428,6	**12457,8**
	Total	**1787,5**		**742,9**	**11020,9**	**7932,6**	**628,5**	**2212,2**	**2683,0**	**1198,8**	**28206,5**
India	Green	1035,8	2216,0		1473,8	1399,8	1040,2	2222,2	1034,0	586,6	**11008,4**
	Blue	193,4	355,7		145,3	241,8	111,0	445,9	299,1	267,3	**2059,4**
	Grey	209,9	353,2		210,2	190,7	115,5	269,2	212,0	125,4	**1686,2**
	Total	**1439,2**	**2924,9**		**1829,2**	**1832,3**	**1266,7**	**2937,3**	**1545,1**	**979,2**	**14753,9**
Japan	Green	3,0	55,6	1,1		60,8	44,9	37,0	9,4	5,2	**217,0**
	Blue	0,9	22,5	1,3		17,7	11,2	13,5	7,0	4,7	**78,8**
	Grey	6,3	132,3	8,3		105,5	56,4	29,3	41,7	29,4	**409,1**
	Total	**10,1**	**210,4**	**10,7**		**184,0**	**112,4**	**79,8**	**58,0**	**39,3**	**704,9**
Korea	Green	66,6	125,6	5,6	693,2		2,5	43,6	8,8	41,6	**987,4**
	Blue	7,7	51,0	2,6	34,5		2,1	17,0	5,1	19,9	**139,9**
	Grey	20,0	80,5	6,3	202,4		7,0	12,5	12,0	11,8	**352,6**
	Total	**94,3**	**257,0**	**14,6**	**930,1**		**11,5**	**73,1**	**25,9**	**73,3**	**1479,9**
Thailand	Green	541,1	5531,3	265,7	6482,5	2178,5		3854,2	4930,5	933,4	**24717,3**
	Blue	103,2	652,8	29,3	767,1	270,7		720,3	606,6	137,3	**3287,3**
	Grey	25,8	394,0	36,7	680,2	145,0		219,3	359,0	89,4	**1949,3**
	Total	**670,2**	**6578,0**	**331,7**	**7929,7**	**2594,2**		**4793,8**	**5896,1**	**1160,1**	**29953,9**
Indonesia	Green	460,2	3490,4	4045,2	5406,6	2630,6	282,4		3127,4	612,4	**20055,1**
	Blue	4,6	11,6	5,5	28,5	82,5	3,1		17,7	11,7	**165,3**
	Grey	16,4	138,7	182,6	185,9	123,2	22,8		148,1	37,9	**855,6**
	Total	**481,2**	**3640,7**	**4233,3**	**5620,9**	**2836,3**	**308,2**		**3293,3**	**662,1**	**21076,0**
Malaysia	Green	738,4	9172,1	5344,4	2355,6	2236,1	492,7	809,8		465,1	**21614,3**
	Blue	8,0	13,2	8,1	18,4	5,1	24,2	79,0		13,3	**169,4**
	Grey	31,3	417,4	243,9	359,6	122,2	131,6	83,9		58,9	**1448,7**
	Total	**777,7**	**9602,6**	**5596,4**	**2733,7**	**2363,4**	**648,5**	**972,7**		**537,3**	**23232,4**
Philippines	Green	14,0	424,8	14,4	1350,8	510,6	44,4	241,5	499,3		**3099,8**
	Blue	0,2	15,9	0,9	70,9	14,9	15,7	6,5	22,7		**147,7**
	Grey	3,1	304,3	16,6	1336,1	217,2	267,8	51,9	408,2		**2605,4**
	Total	**17,3**	**745,0**	**31,9**	**2757,8**	**742,7**	**327,9**	**299,9**	**930,3**		**5852,9**

Table C6 – Total virtual water trade among largest APR countries, mln cubic meters, 2006-2010

		Russia	China	India	Japan	Korea	Thailand	Indonesia	Malaysia	Philippines	Total exports to 8 partners
Russia	Green		31,3	1664,8	82,9	79,8	68,8	206,1	11,8	95,5	**2241,0**
	Blue		19,4	65,5	7,8	13,0	7,4	6,7	2,9	4,2	**126,9**
	Grey		360,9	913,8	119,7	233,3	125,7	83,5	54,2	58,9	**1950,0**
	Total		**411,5**	**2644,1**	**210,4**	**326,2**	**201,9**	**296,3**	**68,9**	**158,6**	**4317,8**
China	Green	1060,9		371,2	4858,7	3859,3	618,7	1030,4	987,7	743,2	**13530,2**
	Blue	288,8		269,6	1296,8	1164,8	165,0	238,7	233,0	199,0	**3855,8**
	Grey	3264,9		3453,8	12723,7	7507,7	1779,3	1911,6	2507,8	1148,4	**34297,3**
	Total	**4614,6**		**4094,6**	**18879,3**	**12531,8**	**2563,1**	**3180,7**	**3728,4**	**2090,7**	**51683,3**
India	Green	537,1	12549,1		2940,4	2112,2	1998,2	3320,9	3091,9	491,9	**27041,7**
	Blue	97,1	3347,7		139,0	277,8	295,9	522,4	406,8	40,0	**5126,7**
	Grey	236,2	2140,7		397,0	406,7	352,4	606,4	619,3	139,9	**4898,7**
	Total	**870,4**	**18037,5**		**3476,4**	**2796,6**	**2646,6**	**4449,8**	**4118,0**	**671,8**	**37067,1**
Japan	Green	8,0	82,4	1,0		98,3	47,9	12,1	12,9	14,5	**277,3**
	Blue	5,2	60,7	3,6		30,5	16,5	6,0	7,8	5,1	**135,4**
	Grey	33,3	364,6	22,2		181,9	92,8	36,5	47,8	31,2	**810,2**
	Total	**46,5**	**507,7**	**26,7**		**310,7**	**157,2**	**54,7**	**68,6**	**50,8**	**1222,9**
Korea	Green	63,9	273,5	3,0	748,1		3,8	41,8	38,5	31,3	**1203,9**
	Blue	9,0	133,5	5,7	46,8		4,3	14,4	5,3	15,4	**234,4**
	Grey	38,9	268,9	22,5	225,4		14,1	15,9	16,1	14,9	**616,7**
	Total	**111,8**	**675,8**	**31,1**	**1020,4**		**22,3**	**72,1**	**59,8**	**61,6**	**2055,0**
Thailand	Green	386,6	10897,5	824,5	5829,4	3805,0		3467,3	6694,0	2241,1	**34145,4**
	Blue	68,1	1041,3	92,7	712,8	220,6		572,9	706,6	265,7	**3680,8**
	Grey	44,8	1090,9	152,8	902,1	181,0		362,6	633,4	192,7	**3560,2**
	Total	**499,5**	**13029,6**	**1070,0**	**7444,4**	**4206,6**		**4402,7**	**8034,0**	**2699,4**	**41386,3**
Indonesia	Green	1084,3	8549,8	12592,4	9192,1	2966,7	524,3		8394,3	1390,6	**44694,5**
	Blue	12,3	6,7	39,5	30,5	81,8	8,0		21,5	21,7	**222,1**
	Grey	40,8	435,5	467,8	292,1	136,8	40,4		355,4	76,3	**1845,2**
	Total	**1137,4**	**8992,0**	**13099,8**	**9514,8**	**3185,3**	**572,7**		**8771,3**	**1488,6**	**46761,8**
Malaysia	Green	1307,3	20494,4	3377,2	3152,7	2268,9	1083,6	1272,0		1361,4	**34317,4**
	Blue	10,2	41,9	11,5	22,1	14,0	40,2	103,3		24,2	**267,4**
	Grey	64,5	1147,9	227,8	448,5	168,1	294,8	182,8		107,4	**2641,9**
	Total	**1382,0**	**21684,2**	**3616,5**	**3623,2**	**2450,9**	**1418,6**	**1558,1**		**1493,0**	**37226,7**
Philippines	Green	29,5	560,7	33,3	1507,0	648,2	107,6	133,0	381,0		**3400,3**
	Blue	0,2	57,5	3,2	92,4	20,4	21,2	12,6	26,6		**234,1**
	Grey	5,3	1095,8	58,0	1702,2	362,2	286,6	103,0	456,7		**4069,7**
	Total	**35,0**	**1714,0**	**94,4**	**3301,6**	**1030,7**	**415,4**	**248,6**	**864,3**		**7704,1**

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