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Research Article

The Comparison of Virtual Water Consumption among the Various Consumption Patterns of Diet

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Abstract: Water resource is the basic and necessary input in the process of production and various consumption patterns of products and goods causes cause different impacts on the water resource using. It is very important to analysis and measures those different influences, which is especially good for the sustainability of water resource, construction of sustainable consumption pattern and the implementation of Integrated Water Resource Management. In this text, the virtual water consumption of Gansu in 1992-2005 is taken as a case study to analysis the relationship between the consumption pattern and virtual water. Then, three replaceable patterns presumed to examine and measure the change of virtual water. Based the results of this study, the per capita virtual water have decreased 43% and the total virtual water 40% in 2005 (relative to 1992). The quantity of food consumption decreases and the milk increases evidently. The key issue to decline the virtual water is the per capita virtual water consumption taken as the "quality" aspect of the virtual water and the more vegetable less meat can save virtual water 9% utmost.

Keywords: Consumption pattern, diet, the product chain, virtual water, virtual water saving

INTRODUCTION

Virtual water refers to the amount of water needed in production of goods and services, introduced by Tony Allen in 1993 (Allan, 1993). Virtual water is not the true sense of the water, because it is included in the product embodied in the form of virtual, Consumers cannot see the shadow of the water from the product. Virtual water was also known as "embedded water" and "foreign water". "Foreign water" means the fact those national imports of virtual water using the non-domestic water. After nearly 10 years of time, the scientific community is increasingly recognizing the importance of the concept of virtual water to balance regional and global water security (Allan, 2003). At present, the virtual water research work in quantitative products virtual water, water footprint and virtual water trade to save water and virtual water reserves and other aspects in depth. Research on consumption patterns of virtual water and water footprint is also widely expanded, Hoeksra in his latest research results show that the water footprint in the United States is about three times higher than China (Chapagain and Hoekstra, 2007). The main cause of this difference is that the total consumption, consumption patterns and climate change and agricultural productivity.

Virtual water is calculated using the account to explain the way in social and economic systems of water migration and conversion and examine products and services embedded in water. Virtual water calculations include: calculation of the virtual water content of crops and calculation of the virtual water content of animal products (Hoekstra and Hung, 2002). On classification of agricultural products and agricultural products virtual water calculation see references, on animal products virtual water calculation method and process also see the reference.

Water is the basis and necessary investment for the production. Different product consumption patterns has a big impact on water resources utilization and oriented, it's important to analyze virtual water consumption characteristics, determine the impact of consumption patterns on water use. Recent discussion on virtual water consumption patterns, mainly from the virtual water consumption and consumer relationships between diversity, gradual improvement in the standard of living, to discuss the impact of consumption patterns on virtual water consumption, but does not specify how to improve virtual water consumption patterns in order to reduce consumption. The content of this article mainly focuses on accounting for changes in consumption patterns to reduce the effect of virtual water consumption (Xu and Zhang, 2014). After a brief introduction of virtual water concept and calculation methods, we taking the virtual water in Gansu Province from 1992 to 2005 mainly consumer goods as the example, estimates the consumption patterns change on virtual water consumption.

METHODS AND CALCULATION

Per capita consumption virtual water of diet: Gansu Province is located in the northwest arid area. The dry climate, low rainfall, strong evaporation and water

Table 1: Virtual water consumption of diet in Gansu (m^3/yr)

	Food	Oil	Pork	Beef	Egg
1992	558.9	87.4	74.6	51.6	85.3
1993	328.1	86.3	76.0	28.8	79.9
1994	441.7	104.9	75.1	34.6	89.9
1995	347.7	87.5	51.2	26.6	70.7
1996	242.4	70.5	48.1	26.8	59.0
1997	250.5	69.8	40.8	32.2	75.6
1998	205.0	52.0	43.3	29.2	69.0
1999	208.3	60.3	48.3	24.0	79.9
2000	206.5	52.0	45.6	24.6	83.3
2001	189.0	58.7	43.6	25.8	76.6
2002	187.5	61.8	45.6	22.6	79.4
2003	173.9	67.6	47.1	23.0	87.6
2004	168.4	64.0	44.0	34.0	77.8
2005	154.8	63.9	43.9	34.2	84.0
	Fish	Vegetable	Sugar	Fruit	Milk
1992	16.1	19.0	2.6	197.0	21.3
1993	13.8	15.8	3.3	160.2	20.6
1994	17.5	17.8	2.9	138.1	21.3
1995	16.0	16.0	3.2	108.7	20.0
1996	11.2	13.6	2.8	95.4	19.0
1997	11.8	13.9	2.8	101.4	20.0
1998	12.9	14.5	2.8	104.6	23.7
1999	15.2	13.5	3.0	104.5	29.4
2000	13.6	12.8	3.1	91.9	37.1
2001	18.8	10.2	3.2	99.2	42.3
2002	17.3	16.4	3.1	93.1	50.5
2003	16.7	14.8	3.3	90.4	67.9
2004	16.0	14.1	3.3	87.7	71.0
2005	16.8	11.5	3.3	88.7	72.0

Table 2: The virtual water consumption of Gansu (m^3/yr)

Year	Per capita	Total
1992	1220.3	2824.0
1993	928.1	2176.5
1994	1049.0	2494.7
1995	840.6	2049.4
1996	681.4	1680.8
1997	710.2	1771.4
1998	644.8	1624.5
1999	701.3	1783.0
2000	677.8	1733.0
2001	668.0	1720.4
2002	677.6	1756.7
2003	704.0	1832.5
2004	709.5	1858.0
2005	697.7	1810.2

shortage has not only become a major constraint for the region's economic development and social progress, but also important cause deterioration of the ecological environment in the region. With the implementation of the western development strategy, the acceleration of population growth, economic development and expansion of eco-environment construction increase, the water shortage will become more prominent. Calculate the virtual water content of agricultural and animal products in accordance with the method described above, for some industrial products virtual water content of previous research results. Make use of the Gansu Province Statistical Yearbook statistics in the provincial average level of consumption, calculated Gansu Province virtual water consumption from 1992 to 2005, the results shown in Table 1.

As the result from Table 1, the province's average per capita consumption of virtual water was in reducing in these 14 years. Compared with 1992, the per capita consumption decreased 43% in 2005. Compared with the 1992 level, the reduced virtual water consumption in most consumer food products is significantly decreased by 72%, followed by fruits (55%), wine (55%), pork (41%) and vegetables (39%) beef (34%) and other trends are more pronounced reduction Dairy registered the largest increase, increases by a factor of 2.4 times compared with 1992, lamb (40%), carbonated beverages (50%) increased considerably. At the same time, compare with the situation changes in the physical consumption, we discovered that food, pork, beef, vegetables, etc. reduced greatly, compared with 1992 consumption levels, were reduced by 60, 41, 33 and 30%, respectively. Meanwhile, lamb, milk and other at a growth rate of 40, 238%. By contrast changes the amount of virtual water per capita consumption and the amount of physical elimination, we can found that the main factor of virtual water change is real consumption, some extent reflect the nature of the production technology of virtual water content of the physical volume of the unit have the less impact on the virtual water consumption change.

Total virtual water consumption: Using each year the province's total population and per capita consumption of virtual water, we can get virtual total water consumption. In the past 14 years, the total population of Gansu Province from 2314.19 million in 1992, an increase of 2594.36 million in 2005, an increase of 12%. We can see a significant reduction in the total amount of virtual water consumption from the calculation results of the virtual total water consumption in Table 2. Relative to the level of 1992, the Virtual water consumption reduced of 40%. We can see that the proportion is very similar to the virtual water consumption per capita reduction rates in front of the analysis.

Comparing with the Per capita consumption of virtual water, the total of virtual water consumption and the trends of demographic changes, we can find that the trend between per capita consumption and total consumption is very similar, both showed a decline in the trend from1992 to 1998, then a slow rise from 1998 to 2005. But the demographic trend raised solely in 14 years.

Total virtual water consumption is virtual water consumption per capita of population data through amplification. Changes in the general population is relatively stable, through its amplification effect, affecting the "quantity"; and changes in per capita consumption of virtual water is from the internal structure of the virtual water consumption, as the result of the function of the "quality". Comparison of virtual per capita consumption, total consumption and population trends of 14 years in Gansu province, has been fully embodies the "quality" and "quantity" phenomenon. Understanding of "quantity" is very vivid,

while understanding of "quality" need to do more research (Xu *et al*., 2002).

Based on the above analysis, we can find that the amount of virtual water per capita consumption trends are very similar to the total amount of virtual water, by amplifying the effect of population on environmental impact, reducing the amount of virtual water per capita consumption is bound to reduce the total amount of virtual water consumption. And if you want to reduce the per capita consumption of virtual water, the most important way is by adjusting consumption patterns, by changing consumption patterns to reduce the amount of virtual water consumption. Rest of this article will attempt to analyze and calculate of the virtual water consumption change after the consumption patterns change, through changing consumption patterns.

VIRTUAL WATER IN DIFFERENT CONSUMPTION PATTERNS OF DIET

Set the consumption pattern adjustment programs: Changes in consumption patterns mainly include two aspects: One is proceeding from the total consumption; the other is proceeding from the structure of consumption. With the development of society and economy, the living standards improve continually, people's consumption demand has been greatly satisfied and consumption is constantly rising. So there are some difficulties to adjust the consumption patterns through controlling the total consumption. To analyze adjustment of consumption patterns become a more common approach from the perspective of changes in consumption structure. According to the latest research report released by "Bioenergy Digest", China's current per capita consumption of meat is 53 kg and was 1.12 times than 1995 Thus the feed grain need to increase nearly one hundred million tons. As such progress, it will make the world food stocks exhausted in 2010, if the United States to close all ethanol plants, period of drought can be deferred to 2013. The report adding that China's per capita meat consumption levels is 45% less than the United States, if the Chinese people eat meat as much as the Americans, the world needs an additional 277 million tons of feed grain and 68 million acres of arable land. From the point of this Digest view, the amount carnivorous ones is a common problem both in developed and developing countries. From virtual water theory, the higher the position of the product chain products, the higher the virtual water content. For example, the virtual water content of corn, wheat, rice (shelled) were 900, 1300, 3000 m^3/ton, while the virtual water content of chicken, pork and beef were 3900, 4900, 15500 m^3/ton. From the above analysis, in order to reduce the consumption of virtual water, adjustment of consumption patterns should give priority to reduce the meat product consumption that content high virtual water. Meanwhile, changing consumption patterns adjustment is not random, should comply with certain principles. Several consumption patterns adjustment programs set in Table 3, in accordance with the principles of calorie intake invariant, changing the ratio of meat products and vegetable products, reducing current consumption patterns in consumption of meat products and increasing vegetable consumption.

Table 3: The three presumed replaceable consumption patterns (m^3/yr)

Consumption patterns	How to
Pattern 0*	Actual consumption
Pattern 1	Meat 75%, vegetable 200%
Pattern 2	Meat 30%, vegetable 260%
Pattern 3	Meat 50%, vegetable 400%

*: Pattern adjustment scheme principle is Kaluri calories

Analysis on virtual water saving: Using the virtual water calculation method applied in preamble and combining with relevant statistical data Gansu over the past 14 years, we account separately virtual water consumption per capita consumption and the total consumption of virtual water in three kinds of adjustment programs. Table 4 shows the virtual water consumption actual changes that three types of consumption patterns adjustment programs relative to the actual consumption patterns. We can see from Table 4, compared with the actual consumption in the past 14 years, three kinds of adjustment programs have different degrees reduced the amount of per capita and total consumption of virtual water. In pattern 1, per capita consumption of virtual water reduced by up to 31.41 m^3, the total amount of virtual water reduced by up to 81.48×10^8 m^3, the water saving ratio was 4.5%. In pattern 2, per capita consumption of virtual water reduced by up to 41.87 m^3, the total amount of virtual water reduced by up to 108.64 10^8 m^3, the water saving ratio was 6.0%. Mode 3 is the most obvious effect of water saving, water-saving proportion increased to 9.0%. Meanwhile, for a given year, in three patterns of consumption pattern adjustment programs, the pattern 3 is the most obvious effect of water saving. And in general terms, each effect adjustment programs of water consumption patterns are getting better and better, the more recent years from now, the better water conservation.

Characteristics of consumption pattern of diet: Virtual water consumption patterns are analyzed virtual water consumption patterns of important content. Virtual water consumption characteristics of the main unit via a virtual water consumption expenditures, virtual water consumption diversity index, based on the development of virtual water capacity. Changing consumption patterns is bound to affect the consumption characteristics of virtual water. Due to article length considerations, here only select the virtual water diversity index (H) and based on the development

Table 4: Virtual water saving of each presumed consumption pattern

	Pattern 1			Pattern 2			Pattern 3		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1992	26	60	2	35	80	3	52	120	4
1993	23	54	2	31	72	3	46	107	5
1994	23	56	2	31	74	3	47	112	4
1995	14	34	2	19	46	2	28	69	3
1996	17	43	3	23	57	3	35	86	5
1997	21	51	3	28	69	4	41	103	6
1998	17	43	3	23	57	3	34	85	5
1999	21	54	3	28	72	4	43	108	6
2000	24	61	4	32	81	5	48	122	7
2001	27	70	4	36	93	5	54	139	8
2002	15	39	2	20	52	3	30	79	4
2003	23	59	3	30	78	4	45	118	6
2004	26	68	4	35	91	5	52	137	7
2005	31	81	5	42	109	6	63	163	9

*: Compare to real consumption patterns; (1) is the virtual water per capita savings (m^3); (2) for the total amount of virtual water saving ($10^8 m^3$); (3) for water-saving ratio (%)

Table 5: The virtual water consumption character compared: Presumed patterns

	Pattern 0		Pattern 1		Pattern 2		Pattern 3	
	H	C	H	C	H	C	H	C
1992	1.9	2.9	1.9	2.9	1.8	2.9	1.8	2.9
1993	2.1	2.5	2.1	2.5	2.0	2.4	2.0	2.4
1994	2.0	2.6	2.0	2.7	1.9	2.6	1.9	2.6
1995	2.0	2.2	2.0	2.2	2.0	2.2	1.9	2.1
1996	2.1	1.9	2.1	1.8	2.1	1.8	2.0	1.8
1997	2.1	1.9	2.1	1.9	2.1	1.9	2.0	1.9
1998	2.2	1.8	2.2	1.8	2.2	1.8	2.1	1.8
1999	2.2	2.0	2.2	2.0	2.2	2.0	2.1	1.9
2000	2.2	1.9	2.2	1.9	2.2	1.9	2.2	1.9
2001	2.2	1.9	2.2	1.9	2.2	1.9	2.2	1.8
2002	2.3	2.0	2.3	2.0	2.2	2.0	2.2	1.9
2003	2.3	2.1	2.3	2.1	2.3	2.0	2.2	2.0
2004	2.3	2.1	2.3	2.1	2.3	2.1	2.3	2.0
2005	2.3	2.1	2.3	2.1	2.3	2.0	2.3	2.0

of virtual water Capacity (C) to analyze changes in the characteristics of virtual water consumption (Ulanowicz, 1997). Documents related to the calculation methods. Table 5 shows three kinds of virtual water consumption adjustment programs and development capacity diversity index calculations.

From the results in Table 5, we can found that three patterns of consumption adjustment programs is very close to the actual pattern of virtual water consumption index and the trends of capacity development. On virtual water consumption diversity index, the overall trend in the three adjustment programs and real situations change are increasing year by year. For each specific year terms, compared with the actual consumption, diversity index in pattern 1 did not change significantly, reduce to a lesser extent. Diversity index in pattern 2 reduced obviously. The diversity index sharpest decline was 4% in pattern 3. For the three pattern s with the actual situation of the hair the ability to measure, the overall performance of an upward trend after the first drop in the three adjustment programs, Development capacity to decline a maximum of 6% in pattern 3.

DISCUSSION AND CONCLUSION

Conclusion: Virtual water concept provides a new perspective to solve water problems revolutionizes the traditional study of water on the water, promotes further coupling of water resources and social economy system, but also for water resources management in the process of socialization. The paper briefly introduces the virtual water concept, method and research progress, take Gansu province as an example to calculate the virtual water consumption from 1992 to 2005. After that, combined with an analysis of current consumption patterns, set three adjustment programs of consumption patterns, estimates the virtual water-saving effect of different adjustment programs. Finally, from the virtual water consumption diversity and development capacity, comparing the changes in the virtual water consumption characteristics of the three adjustment programs. Increase or decrease in The amount of material consumption is the main factor affecting the amount of virtual water consumption changes. In these 14 years, per capita consumption of virtual water has decreased, compared with 1992 per capita consumption is reduced by 43% in 2005. In

Consumption items, virtual water consumption is reduced the most significant for food products and dairy rises is the largest. Control the "quality" of per capita virtual water consumption is the key to reducing the “amount" of consumption of virtual water. Total virtual water consumption is virtual water consumption per capita of population data through amplification. Eat more vegetables and less meat, alternative low tropic level products with higher tropic level products. Compared with actual consumption in the past 14 years, three kinds of adjustment programs have different degrees reduced the amount of per capita and total consumption of virtual water. Water-saving proportions of the three modes, respectively 4.5, 6.0 and 9.0%, respectively. Meanwhile, after a change in consumption patterns, the virtual water consumption characteristics have also changed.

Discussion: Sustainable production and sustainable consumption are two important researches for sustainable development, however, due to the market economic conditions, consumer behavior will guide the production behavior. Therefore, from a certain sense, sustainable consumption is more important than sustainable production. Sustainable consumption refers to consumer attitudes, consumption patterns and consumer behavior that meet people's physical and mental health and overall development requirements, promote socio-economic development, pursue harmony between human beings and nature. Achievement of Win-win "developmental" and "sustainability" consumption is essential connotation of sustainable consumption.

In terms of the relationship between man and nature, consumption of "sustainability" mainly refers to the ecological carrying capacity cannot exceed the limit when contemporary people to meet the development needs of the consumer, Consumption should be conducive to environmental protection, in favor of the ecological balance. It required to achieve optimal and sustainable use of resources, but also required to realize minimum waste emissions and minimal environmental pollution. Undoubtedly, the ecological environment carrying capacity once breakthrough, consumption, of course, has no "sustainability."

In terms of the relationship between people and consumption, “Sustainability” of consumption mainly refers to the fair and equitable consumption. Sustainable consumption is not a compromise between the insufficient consumption caused by poverty and excessive consumption caused by the rich, but a new consumption patterns. It embodies the principle of fairness and justice, that is, the pursuit of quality of life for each and every one of the contemporary world, for each and every one of his contemporaries and successors should enjoy equally. Anyone should not be endangering the survival of others consumption because of own consumption (intergenerational fairness), modern man should not be this generation's spending and endangering the survival of future generations and consumer (that is, intergenerational equity).

Sustainable consumption must be developed, so that the stagnated consumption is not sustainable consumption. At present, the international community generally believes that the "zero growth" seeing the traditional theory of economic growth could harm, humans are not the way out of "zero growth", but sustainable development. Similarly, the existing consumption patterns left unchecked may lead to a series of major harm, but the "zero growth" is not intended to sustainable consumption, not to mention consumer backwards. Therefore, sustainable consumption for our existing consumer attitudes, consumption habits and consumption structure and consumption methods put forward new requirements: it is necessary to oppose overly frugal, only to meet the food and clothing to the neglect of "development" of consumption; also oppose extravagance consumption, especially against uncontrolled manner to focus only on material comforts, ignoring the ecological constraints, ignoring the constraints of social justice that ignore consumer "sustainability."

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