Study on the water footprint and external water dependency of Beijing
Yanzhi Sun, Lei Shen and Chunxia Lu

ABSTRACT

Beijing has experienced rapid economic development and population growth during recent decades, aggravating water scarcity. In order to investigate the water consumption of Beijing, this paper quantitatively evaluates the water footprint (WF), the intensity of the water footprint (Iwf) and the external water dependency (WD) based on the top-down and bottom-up methods. We obtain the following major conclusions: (1) the total WF in Beijing is 353 10⁸ m³ in 2012; per capita WF is 1,704 m³, which is 8 times that of the entity water of Beijing; (2) the Iwf in Beijing rises after 2007, indicating that there remains a great potential for improving water-use efficiency; (3) through virtual water trade, the external WF takes over 70% of the total WF annually; therefore, Beijing has faced more severe water resource stress recently; (4) through the spatial analysis of external WD, we identify that in each side of the Hu line, distribution of distance of the flow of imported virtual water shows homogeneity, and that WD in the southeast region is high and in the northwest is weak.

Key words | Beijing, external water dependency, virtual water trade, water footprint, water scarcity

INTRODUCTION

Global freshwater resources are under increasing shortage pressure at the current human consumption (Dalín et al. 2012). Therefore, it is essential to measure and evaluate the efficiency of water consumption. Water footprint (WF) is the most comprehensive and advanced indicator of water consumption (Huang et al. 2012). An accurate description and analysis of the water consumption by WF may deepen understanding of our water consumption behavior.

The virtual water refers to the volume of water contained in a product (a commodity, good or service) and virtual water ‘trade’ represents the amount of water embedded in traded products (Allan 1995; Hoekstra & Hung 2005). It can relieve the water scarcity in water-poor regions through importing water from water-rich regions (Feng et al. 2012). WF derives from the conception of virtual water and was first proposed by Hoekstra (2003). It comprises the direct and indirect water resource, which is an indicator of freshwater for producing the goods and services consumed by the individual or community (Chapagain & OrrAn 2009).

There are three primary aspects about the research on WF, as follows:

1. WF assessment. On the one hand, some studies focus on the calculation of regional total WF. For instance, the total WF of China is 856 10⁸ m³ and the per capita WF is 648 m³ in 2007 (Ge et al. 2011), and the spatial distribution of WF is non-uniform, especially in urban areas in which the WF is higher than the rural household (Feng et al. 2012). It is also found that WF is affected by factors such as economic development, population growth, per capita water usage and the consumption structure of residents (Jenerette et al. 2006). On the other hand, the water required for some products have been studied in detail. There are some studies focusing on cotton (Chapagain et al. 2006), biofuel (Chiu & Wu 2012), coffee and tea (Chapagain & Hoekstra 2007), livestock products (Mekonnen & Hoekstra 2012), wine and beverages (Ercin et al. 2011).

2. Method of WF evaluation. There are two primary methods used to calculate WF, including the top-down
(Dong et al. 2015) and bottom-up (Chapagain & OrrAn 2009) methods. The bottom-up method depends on the quality of the consumption data, while the top-down method relies on the quality of trade data. The top-down method is more commonly used and it consists of the internal and external WF, but there exists the sector aggregation error (Okadera et al. 2015). In contrast, the bottom-up method is rarely used to evaluate the WF.

3. Virtual water trade. The international trade of water-intensive products (e.g. agricultural commodities) or virtual water has been suggested as a way to save water globally (Dalin et al. 2012). D’Odorico et al. (2012) discovered that the structure of the virtual water trade network is formed in a process termed ‘globalization of water’ and the virtual water trade sustains the development of the region. However, the drivers of the virtual water fluxes are not identified adequately (D’Odorico et al. 2012).

The Chinese context

The water resources of China account for 6% of the world’s total, ranking the fourth. However, the per-capita water resources ranks 121st, only a quarter of the world’s average level (Ge et al. 2011), which makes it one of the thirteen water scarce countries in the world. As Beijing is the capital of China, the research on its water consumption seems to be of top significance. In 2014, the per capita water resources of Beijing are less than 200 m³, which is only equal to one-tenth that of China and far below the internationally recognized lower limit of 1,000 m³. Due to rapid urbanization, water shortage will restrict the potential for the sustainable development of Beijing. Therefore, it is indispensable to measure the WF of Beijing to regulate the water resource consumption reasonably.

The conception of virtual water was introduced into China in 2003 initially, and the virtual water trade can be considered as the available way to relieve China’s water scarcity and guarantee water security. Although China as a whole is a net virtual water exporter, the agricultural sector is a net importer. In Beijing, over 50% of the total WF comes from external sources, and agriculture has the highest proportion in external sources (Zhang et al. 2011). Liu & Kang (2007) studied the WF of Beijing and suggested that the virtual water inflow can decrease the ecological pressure and promote regional water sustainability.

Previous research enriches the content of WF study (Chapagain et al. 2006; Mekonnen & Hoekstra 2012; Ridoutt & Pfister 2013); however, few studies refer to the virtual water flow distance. Based on the study of Xie et al. (2014), we propose a conception of the distance of the flow of imported virtual water (Dfi), combining the volume of virtual water with the virtual water flow distance, to enhance the research of the virtual water flow distance. In order to investigate the water consumption of Beijing and the virtual water flow, we combine the bottom-up with the top-down method to quantify the WF during 2002–2012, and employ the Dfi to depict the external water dependency (WD) of Beijing spatially based on the survey data form the Agro Wholesale Market. It provides us with a better understanding of the interregional supply–demand relationship of the water source and serves as a reference for mitigating the water scarcity of Beijing.

METHODOLOGY AND DATA

Methodology

WF evaluation

In this study, different from previous studies, we combine the top-down with the bottom-up method to calculate the WF. According to the top-down method, WF is divided into internal and external WF and we employ the bottom-up method to calculate these two parts. Internal WF contains the entity water (the domestic water, the industrial water and the environmental water) and virtual water. Generally speaking, the virtual water includes the agricultural virtual water and industrial virtual water. Because of the poor data availability and the complex production process of the industrial products, in this paper, we use the industrial water to represent the industrial virtual water. While the external WF is the virtual water for importing. The procedure for WF calculation is shown in Figure 1.

Agricultural water footprint (AWF) can be calculated by the crop water required (CWR) and the area of crops (A). To calculating the CWR, first, we apply the Penman–Monteith
formula recommended by the Food and Agriculture Organization of the United Nations to calculate the reference evapotranspiration ($ET_0$). And then the actual evapotranspiration ($ET_c$) is acquired based on the $ET_0$ and the crop coefficient ($Kc$). Summing up the $ET_c$ of all crop-growing stages, CWR is attained. The calculation process of each parameter is represented by the following equations.

1. $ET_0$ calculation

$$ET_0 = \frac{0.408\Delta(Rn - G) + \gamma \frac{900}{T + 273} U_2 (e_s - e_a)}{\Delta + \gamma (1 + 0.34U_2)} \quad (1)$$

where $ET_0$ is the reference evapotranspiration (mm·d$^{-1}$); $Rn$ is the surface net radiation (MJ·m$^{-2}$·d$^{-1}$); $G$ is soil heat flux (MJ·m$^{-2}$·d$^{-1}$); $T$ is the average daily temperature at an altitude of 2 m (°C); $U_2$ is the wind speed at an altitude of 2 m (m·s$^{-1}$); $e_s$ is saturation water vapor pressure (kPa); $e_a$ is the actual water pressure (kPa); $\Delta$: is the rate of curve of saturation water vapor pressure (kPa·°C$^{-1}$); $\gamma$ is the psychomotor constant (kPa·°C$^{-1}$).

2. $ET_c$ calculation

$ET_c$ represents the actual evapotranspiration (mm·d$^{-1}$), and it is estimated by $ET_0$ and $Kc$, shown in the following formula:

$$ET_c = Kc \cdot ET_0 \quad (2)$$

3. AWF calculation

$AWF$ (m$^3$) comes from multiplying CWR (mm) by $S$ (m$^2$), and CWR is the sum of $ET_c$ all stages in crop growing. The equation is:

$$AWF = CWR \cdot S = \sum ET_c \cdot S \quad (3)$$

Then the quantity of virtual water embodied in per unit crop (VWC, m$^3$) can be calculated as follows:

$$VWC = \frac{AWF}{Q} \quad (4)$$

where $Q$ is the amount of crop products (kg).

The virtual water volume of Xinfadi market ($MWF$, m$^3$) can be acquired by the VWC and the amount of agricultural products ($q$, kg) from Xinfadi market, and it can be expressed as Equation (5):

$$MWF = VWC \cdot q \quad (5)$$

Intensity of water footprint

The intensity of the water footprint ($Iwf$) manifests as the ratio of WF and gross regional production (GDP, Yuan). The formula is:

$$Iwf = \frac{WF}{GDP} \quad (6)$$
Iwf (m³/million Yuan) can reflect the water usage efficiency in a certain country or region (1 Yuan ≈ 0.16 USD).

External WD

External WD (%) is the ratio between external WF and the gross WF and indicates the degree of water dependence on the external footprint. The formula is:

\[ WD = \frac{\text{External water footprint}}{\text{Water footprint}} \quad (7) \]

\( D \) can be represented by the following formula (8). It reflects the supply–demand relationship between the study area and other regions through the water volume and flow distance. It can be defined as:

\[ D_i = D \times V_i \quad (8) \]

\( D \) is the linear distance from other provincial capitals to Beijing, and \( V_i \) represents the flowing volume of imported virtual water from the external provinces.

Data source

To quantify the WF, the Iwf and WD of Beijing, the following data are required:

1. Meteorological data. These data are used to calculate per unit virtual water volume and are acquired from CROPWAT software exploited by the FAOSTAT (http://faostat.fao.org).
2. Statistical data. The statistical data include volume of water, GDP, yield and trade of crops. Data on water resources comprise the domestic water, the industrial water and the environmental water. All of the data are obtained from the Statistical Yearbooks of Beijing (2000–2013).
3. Survey data. As the imported virtual water is transported to the farm product markets and then distributed to other places within the city and the Xinfadi Agro Wholesale Market provides 70% of vegetable supply and 80% of fruit for Beijing, and takes 81% of market share in 2010, its agricultural trade situation can basically reflect the condition of the whole city. Considering the representativeness of the Xinfadi Agro Wholesale Market, we collect the data from Xinfadi, including the trade data on vegetable, fruit, livestock, aquarium and crop products.
4. Other data. The virtual water volume of animal products in Beijing refers to the study by Chapagain & Hoekstra (2003).

RESULTS AND DISCUSSION

Total WF

According to our study, the WF is 106 \( 10^8 \) m³/year in 2002, higher than the result of 86 \( 10^8 \) m³/year from Wang et al. (2011). The difference may be caused by the WF calculation methods. Wang et al. (2011) applied the input–output table to analyze the WF and some water using sectors may be left out, leading to the fact that the WF calculated by Wang et al. (2011) is lower than ours. In 2012, 68 \( 10^8 \) m³ water resources from inside Beijing are consumed, exceeding the statistical data of water consumption (36 \( 10^8 \) m³). Meanwhile, per capita WF is 1,704 m³, which is also much more than the statistical data (193 m³). The indirect water consumption takes a great part of actual consumption, and it makes a gap between WF and entity water.

From 2002 to 2012, the average imported WF of Beijing is 58%, which is consistent with the findings of Zhang et al. (2011). In a different period, the net imported virtual water of Beijing appears to fluctuate (Table 1). (1) During 2002–2004, the volume of net imported virtual water rises from 36 \( 10^8 \) m³ to 176 \( 10^8 \) m³, which accounts for 71% of the total WF in 2004. (2) During 2004–2007, however, it descends from this summit to 32 \( 10^8 \) m³. (3) During 2007–2012, it shows an increasing tendency for the net imported virtual water and it reaches 285 \( 10^8 \) m³ (81%) in 2012.

From 2002 to 2012, the population of Beijing increases by nearly 10 million and per capita GDP rises from 30,730 to 87,475 Yuan, which may lead to the higher purchasing potential and more food consumption. Meanwhile, the yield of vegetables (from 507 \( 10^4 \) t to 280 \( 10^4 \) t) and meat (from 71 \( 10^4 \) t to 43 \( 10^4 \) t) in Beijing is reducing. More crop goods have to be imported into Beijing because the internal food supply can’t meet the demand of domestic residents. Thereupon, the importation promotes the net imported virtual water. However, in 2007, because of the
foreign trade barrier and the appreciation of the currency in China, more water-intensive goods (oil plants and maize) are exported, and the imported soybean, dried beans and cotton decrease substantially; consequently, a reduction of the net imported virtual water occurs.

Iwf

The Iwf indicates water-use efficiency and the smaller Iwf reflects a higher water-use efficiency. Iwf in Beijing fluctuates dramatically during 2002–2012 (Table 2). Before 2004, the Iwf displays a growing tendency and reaches the summit (410 m³/million Yuan) in 2004. And then the Iwf drops to the nadir (99 m³/million Yuan) in 2007. A little change but a slight ascent occurs in the period 2007–2012 with an average annual 150 m³/million Yuan.

Iwf is affected by the WF and GDP, and as the GDP is increasing during the period 2002–2012, the WF becomes the main factor influencing the variation of Iwf. Factors, such as the economic and population growth as well as a dramatic shift in the food structure to consume more meat, drive the WF up, increasing consumption of agricultural production, especially livestock product consumption, which takes about 58% of AWF.

External WD

WD expresses the water dependence on external water footprint, which ranges from 0 to 1 (1 represents the strongest water dependence on the external and 0 represents the weakest water dependence on the external). Table 3 illustrates that, in Beijing, there are two obvious turning points in the change trend of external WD during 2002–2012. Before 2007, WD increases stably with an annual WD of 77%. From 2007 to

---

**Table 1** The WF in Beijing from 2002 to 2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Water resource (10^8 m³)</th>
<th>Entity water</th>
<th>AWF</th>
<th>Net imported virtual water</th>
<th>Total WF</th>
<th>Per capita WF (m³)</th>
<th>Composition of water (%)</th>
<th>Entity water</th>
<th>AWF</th>
<th>Net imported virtual water</th>
<th>Total WF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>19</td>
<td>51</td>
<td>36</td>
<td>106</td>
<td>744</td>
<td></td>
<td></td>
<td>18</td>
<td>48</td>
<td>34</td>
<td>100</td>
</tr>
<tr>
<td>2003</td>
<td>22</td>
<td>50</td>
<td>48</td>
<td>120</td>
<td>824</td>
<td></td>
<td></td>
<td>18</td>
<td>42</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>2004</td>
<td>21</td>
<td>49</td>
<td>176</td>
<td>247</td>
<td>1,656</td>
<td></td>
<td></td>
<td>9</td>
<td>20</td>
<td>71</td>
<td>100</td>
</tr>
<tr>
<td>2005</td>
<td>22</td>
<td>43</td>
<td>132</td>
<td>202</td>
<td>1,316</td>
<td></td>
<td></td>
<td>11</td>
<td>24</td>
<td>65</td>
<td>100</td>
</tr>
<tr>
<td>2006</td>
<td>22</td>
<td>43</td>
<td>97</td>
<td>161</td>
<td>1,008</td>
<td></td>
<td></td>
<td>13</td>
<td>27</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2007</td>
<td>23</td>
<td>42</td>
<td>113</td>
<td>179</td>
<td>800</td>
<td></td>
<td></td>
<td>17</td>
<td>24</td>
<td>54</td>
<td>100</td>
</tr>
<tr>
<td>2008</td>
<td>24</td>
<td>43</td>
<td>76</td>
<td>143</td>
<td>767</td>
<td></td>
<td></td>
<td>12</td>
<td>30</td>
<td>44</td>
<td>100</td>
</tr>
<tr>
<td>2009</td>
<td>24</td>
<td>42</td>
<td>136</td>
<td>202</td>
<td>1,011</td>
<td></td>
<td></td>
<td>12</td>
<td>30</td>
<td>33</td>
<td>100</td>
</tr>
<tr>
<td>2010</td>
<td>25</td>
<td>41</td>
<td>153</td>
<td>219</td>
<td>1,031</td>
<td></td>
<td></td>
<td>8</td>
<td>21</td>
<td>21</td>
<td>100</td>
</tr>
<tr>
<td>2011</td>
<td>27</td>
<td>41</td>
<td>153</td>
<td>353</td>
<td>1,704</td>
<td></td>
<td></td>
<td>8</td>
<td>19</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

---

**Table 2** The Iwf in Beijing from 2002 to 2012

<table>
<thead>
<tr>
<th>Year</th>
<th>WF (10^8 m³)</th>
<th>GDP (10^8 Yuan)</th>
<th>Iwf (m³/million Yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>106</td>
<td>4,315</td>
<td>245</td>
</tr>
<tr>
<td>2003</td>
<td>120</td>
<td>5,007</td>
<td>240</td>
</tr>
<tr>
<td>2004</td>
<td>247</td>
<td>6,033</td>
<td>410</td>
</tr>
<tr>
<td>2005</td>
<td>202</td>
<td>6,970</td>
<td>290</td>
</tr>
<tr>
<td>2006</td>
<td>161</td>
<td>8,118</td>
<td>199</td>
</tr>
<tr>
<td>2007</td>
<td>97</td>
<td>9,847</td>
<td>99</td>
</tr>
<tr>
<td>2008</td>
<td>179</td>
<td>11,115</td>
<td>161</td>
</tr>
<tr>
<td>2009</td>
<td>143</td>
<td>12,153</td>
<td>117</td>
</tr>
<tr>
<td>2010</td>
<td>202</td>
<td>14,114</td>
<td>143</td>
</tr>
<tr>
<td>2011</td>
<td>219</td>
<td>16,252</td>
<td>135</td>
</tr>
<tr>
<td>2012</td>
<td>353</td>
<td>17,879</td>
<td>197</td>
</tr>
</tbody>
</table>

---

**Table 3** External WD of Beijing from 2002 to 2012

<table>
<thead>
<tr>
<th>Year</th>
<th>External WF (10^8 m³)</th>
<th>WF (10^8 m³)</th>
<th>WD on external (WD) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>58</td>
<td>106</td>
<td>54</td>
</tr>
<tr>
<td>2003</td>
<td>93</td>
<td>120</td>
<td>77</td>
</tr>
<tr>
<td>2004</td>
<td>196</td>
<td>247</td>
<td>80</td>
</tr>
<tr>
<td>2005</td>
<td>167</td>
<td>202</td>
<td>83</td>
</tr>
<tr>
<td>2006</td>
<td>128</td>
<td>161</td>
<td>80</td>
</tr>
<tr>
<td>2007</td>
<td>83</td>
<td>97</td>
<td>86</td>
</tr>
<tr>
<td>2008</td>
<td>125</td>
<td>179</td>
<td>70</td>
</tr>
<tr>
<td>2009</td>
<td>83</td>
<td>143</td>
<td>58</td>
</tr>
<tr>
<td>2010</td>
<td>141</td>
<td>202</td>
<td>70</td>
</tr>
<tr>
<td>2011</td>
<td>157</td>
<td>219</td>
<td>72</td>
</tr>
<tr>
<td>2012</td>
<td>290</td>
<td>353</td>
<td>82</td>
</tr>
</tbody>
</table>
2009, it shows a decreasing tendency, from 86 to 58%. And after 2009, WD increases gradually with an annual WD of 75%.

As the internal WF is rather smaller than the external, WD is mainly influenced by the external WF. The growth of population and economy, the decreased yield of agricultural products, and the higher food demand all promote the external WF, which pushes the WD up.

**Spatial analysis of external WD**

**Sources of the external WF of Beijing**

Spatial analysis of water resource flow offers a better understanding of water resource origin and destination, and it will be beneficial for water management. External WD of Beijing can reflect the virtual water supply–demand relationship between Beijing and other provinces.

According to our study, most of the virtual water flows into Beijing from Hebei, Shandong, Jiangxi and provinces in the northeast of China (Figure 2). Hebei is the largest virtual water supplier, which provides 7,950 $10^4$ m³ virtual water for Beijing annually. The second-most virtual water supplier is Shandong with 5,142 $10^4$ m³. And Shanghai is the least with an average annual virtual water of 13 $10^4$ m³.

Hebei, a water scarce province in China, is the most important ‘water-saving helper’ for Beijing (Zhang et al. 2011). Hebei is rich in fruit production, and the planting area and yield of pear, date, chestnut and peach are the highest in China, so it has great potential to support Beijing in its agricultural products trade. From the perspective of geography, 80% of the boundary of Beijing borders on Hebei, making it particularly convenient for trade of goods and services. Shandong and Jiangxi plays an important role in supplying agricultural products for the whole country,

![Figure 2](https://iwaponline.com/ws/article-pdf/16/4/1077/411617/ws016041077.pdf)
which may explain the large amount of virtual water exported to Beijing.

Dfi

The total Dfi in Beijing is increasing from $2.418 \times 10^8$ m$^3$·km to $3.988 \times 10^8$ m$^3$·km during 2008–2010; then falling to $3.065 \times 10^8$ m$^3$·km in 2011, and in 2012 the Dfi is $3.342 \times 10^8$ m$^3$·km.

Dfi is changing frequently, and more factors affect it, including the distance, regional production conditions, and crop structure. In 2011, the total Dfi descends because of the decrease in Dfi of food, fruitage and livestock products. Variation in agriculture product imports is the single-biggest reason for the change of Dfi.

Figures 3 and 4 elaborate the changes of Dfi in 2008 and 2012. In 2008, Hainan is the highest ($626 \times 10^8$ m$^3$·km) and the average Dfi is $93 \times 10^8$ m$^3$·km. In 2012, Xinjiang is the highest ($501 \times 10^8$ m$^3$·km) and the average Dfi is $129 \times 10^8$ m$^3$·km.

In both 2012 and 2008, on each side of the Hu line (Heihe-Tengchong Line or Aihui-Tengchong Line, proposed by Hu (1935)), the distribution of Dfi shows homogeneity. The Hu Line divides China into two parts: the northwest and southeast regions. Belonging to the arid and semi-arid inland region, the northwest region of China suffers scarce rainfall as well as high evaporation, and it is not suitable for some kinds of agricultural production. In the southeast region, the climate is warmer and moister, and the water resources and land resources relatively richer, which are beneficial to agricultural production. Additionally, with a convenient transportation system, it is conducive to the development of export-oriented agricultural production in the southeast region. Thus, the southeast region of China is the primary provider of products and virtual water for Beijing and the Dfi is relatively higher. In contrast, the northwest of China can only provide less and the Dfi is lower.

Further analysis of primary providers in the southeast region of China, the main ‘water-saving helpers’ for Beijing, may be divided into two categories: the short-distance provinces, like Hebei and Shandong, and the long-distance but abundant in agricultural produce provinces, such as...
Jiangxi and Hainan. Hainan, for instance, is far away from Beijing but rich in fruit, so more virtual water hidden in fruitage is provided from these places to Beijing.

The two figures also show that the Dfi of fruitage accounts for the most in each region; this means that, in Beijing, the structure of imported products is simplex. Basing on the previous study, one possible approach for Beijing to ameliorate the water stress is to internally adjust its consumption structure and externally extend the interregional trade context with other provinces.

**CONCLUSIONS**

This paper evaluates the WF of Beijing combining top-down and bottom-up methods, and it investigates the external WD by the internal and external WF. It also analyzes the spatial distribution of virtual water flow.

The result of WF analysis indicates that there is a great gap between WF and entity water. This gap will be filled by indirect water consumption through the interregional virtual water trade, especially the more water-intensive goods, such as the oil plants, cotton and grain. More of these crop products should be imported into Beijing to reduce agricultural production and conserve water resources.

Through the spatial analysis of WD, we discover that the main water providers are located in the southeast of China, while the provinces in the northwest part of China support less virtual water for Beijing. The WD presents high homogeneity, respectively, on each side of the Hu Line. It is necessary for Beijing to strengthen the regional trade among external provinces, and expand the sources of products and virtual water to mitigate the water stress.

**ACKNOWLEDGEMENTS**

We are grateful to acknowledge the financial support of the Strategic Priority Research Program-Climate Change: Carbon Budget and Related Issues of the Chinese
REFERENCES


Liu, B. & Kang, S. Z. 2007 Studies on virtual water impact to water resources bearing capacity of Beijing Municipality. China Water Resources (8), 8–11.


First received 3 September 2015; accepted in revised form 9 February 2016. Available online 27 February 2016