Abstract: This study administers a survey on available literatures and secondary data sources on shrimp cultivation in Bangladesh. The survey results indicate that there are significant variations in production and area coverage data under shrimp farming in the country. It also finds a lack of uniqueness and uniformity in the available dataset. This study uses the concept of extrapolation and makes some assumptions to confine into a representative and updated dataset of shrimp and prawn cultivated area and production in the south-west region of Bangladesh. The study findings indicate that the calculated shrimp and prawn cultivated area in the region is 0.19 million hectare (ha) with 0.15 million ha minimum and 0.23 million ha maximum values for the year 2011. It also confines the shrimp and prawn production value to 369 million US$ with 155 million US$ minimum and 667 million US$ maximum values in the region for the year 2011. Since there is no consensus yet in the literatures about the shrimp and prawn area coverage and production data, the findings of this study may be a benchmark for future studies.

Keywords: Shrimp cultivation, Area coverage, Production, South-west Bangladesh

Introduction

Shrimp farming is an important economic activity in Bangladesh (UNEP, 1999). It helps to reduce poverty, generate employment and earn foreign exchanges for the country (Huntington, 2003; Masum, 2008; and PRICE, 2010). On the contrary, destruction of mangroves, conversion of rice fields into shrimp ponds, salinization of agricultural lands, deterioration of groundwater quality, drinking water crisis, health hazards, reduction in production of other agricultural crops and livestock resources in the surrounding areas are some adverse social and environmental effects of shrimp farming (Pillay, 1992; Primavera, 1991; and Rajalakshmi, 2002).

Shrimp farming has been expanding in Bangladesh since mid 1980s (Alauddin & Hamid, 1999; DTS, 2006 and Gammage et al., 2005). It has been influencing the socio-economic, institutional, ecological and environmental conditions of the coastal regions of Bangladesh (Barmon et al., 2011). Bagda (P. monodon or shrimp) and golda (M. rosenbergii or prawn) are the two main varieties of shrimp that are cultured in Bangladesh (DTS, 2006; Huntington, 2003; and Khatun, 2004). Bagda is cultivated in brackish water of the coastal regions, while golda is cultivated in fresh water of the country. The available dataset and
studies often consider both the *bagda* and *golda* together instead of describing these two separately. A number of studies, such as Abedin & Kabir (1999), Abedin *et al.* (1997), Ahmed *et al.* (2008), Bhattacharya *et al.* (1999), Haque (2004), and Hasanuzzaman *et al.* (2011) tried to address the shrimp sector of Bangladesh from the economic perspective. These studies mostly consider secondary dataset while evaluating the shrimp sector.

In addition to Bureau of Statistics (BBS) and Department of Fisheries (DOF) of Bangladesh, Alauddin & Hamid (1999), ATDP II (2005), Barraclough & Finger-Stich (1996), DOF (1994), DTS (2006), Khatun (2004), MPO (1986), Nupur (2010), Raux and Bailly (2002), Rosenberry (1995), Sarwar (2005), and NACA (2002) are some important sources that reported shrimp cultivated area and production data in Bangladesh.

However, an intensive review of the said literatures reveals that there are significant variation in production and area coverage dataset under shrimp cultivation in the country. The reporting time for shrimp cultivated area and production data in the said literatures also vary significantly. Therefore, the authors attempt to calculate a representative and updated dataset of shrimp cultivated area and production. Accordingly, the main objective of the study is to construct an updated, representative and comprehensive dataset of shrimp cultivated area and shrimp production in the south-west region of Bangladesh.

**Materials and methods**

This study is mainly based on secondary data. Ahmed *et al.* (2008), Alauddin & Hamid (1999), ATDP II (2005), Barraclough & Finger-Stich (1996), BBS (2007 and 2011), DOF (1994 and 2011), DTS (2006), Hasanuzzaman *et al.* (2011), Huntington (2003), Khatun (2004), MPO (1986), NACA (2002), Nupur (2010), Raux and Bailly (2002), Rosenberry (1995), Sarwar (2005), and Williams & Khan (2001) are the main data sources for the study.

A survey on the available secondary sources indicates that a separate discussion and published dataset on shrimp (*bagda*) sector alone are scarce. Rather, the available sources often discuss both the shrimp and prawn together. Therefore, this study considers both shrimp and prawn (SP) aquaculture together. It is observed that there are variations in quantity, timing as well as units used in quantifying the shrimp production in Bangladesh. Therefore, this study considers 2011 as the study year and tries to convert the available price and monetary data of various years to present value (PV) of the year 2011. Moreover, this study uses 1 US$=80 Tk\textsuperscript{1} exchange rate to convert the ‘PV at Tk’ in US$. The study primarily focuses on the south-west (SW) region of Bangladesh. The Khulna, Satkhira and Bagerhat districts are defined as the SW region of Bangladesh in this study. The basic socio-economic and demographic features of the region are listed in Table 1.

| Item       | Location | Khulna | Bagerhat | Satkhira | SW Region | Bangladesh | Share of SW |
|------------|----------|--------|----------|----------|-----------|------------|-------------|
| Household (No.) |          | 499,324 | 323,505  | 390,745  | 1,213,574 | 25,490,822 | 4.76%       |
| Population (No.) |         | 2,378,971 | 1,549,031 | 1,864,704 | 5,792,706 | 124,355,263 | 4.66%       |
| Area (sq. km)   |          | 4,395   | 3,959    | 3,858    | 12,212    | 147,570    | 8.28%       |
| Literacy rate (%)|         | 57.81   | 58.73    | 45.52    | 46.15     | -          | -           |

\textsuperscript{1}Taka (Tk) is the currency of Bangladesh.

### Table 1: Overview on the SW Region of Bangladesh

Source: BBS (2011) and Authors’ compilation.
The present study also tries to extend the result and predict for the whole SP producing area of the country. It considers Chittagong and Cox’s bazaar districts in addition to the SW region while discussing from Bangladesh perspective. The considered five districts (Khulna, Satkhira, Bagerhat, Chittagong and Cox’s bazaar) cover more than 90 percent of total SP producing areas in the country.

To construct a representative data of SP production, the study uses six approaches, developed by the authors (Fig. 1). The first approach uses total SP production data (in kg) and converts it into million US$ using price data and conversion factor (1 US$=80 Tk). Approach 2 uses total SP cultivated area in hectare (ha) and per unit production (in kg/ha) data and converts it into million US$ following the same method described for Approach 1.

The third and fourth approaches use total SP cultivated area (in ha) and divide it under bagda and gaida categories using available data. The third approach uses per unit production (in kg/ha) data and the fourth approach uses per unit production (in Tk/ha) data. Finally, in both the third and fourth approaches, the calculated results are converted into million US$.

The fifth and sixth approaches use total cultivated area (in ha) and divide it under extensive, semi-intensive and intensive cultivation methods of SP farming using available data. The fifth approach uses per unit production (in kg/ha) data and the sixth approach uses per unit production (in Tk/ha) data. Finally, in both the fifth and sixth approaches, the calculated results are converted into million US$.

![Fig.1: Approaches for quantifying shrimp and prawn (SP) production](image-url)
Fig. 1 briefly describes the considered six approaches. There is no consensus yet in the literatures about which method suits best for calculating the monetary value of produced SP. Moreover, the calculated results vary significantly from each other. Hence, it might be difficult and misleading to advocate for one or more of the said approaches as best fit. For the very reason, the study considers all of these approaches and finally calculates the simple average of these six approaches to confine into a specific number. It also reports the standard deviation of the calculated average value.

**Results and discussion**

**SP cultivated area**

Bangladesh Bureau of Statistics (BBS) and Department of Fisheries (DOF) are the main sources for secondary data on SP cultivated area in Bangladesh. According to BBS and DOF database, SP cultivated areas are 0.16 and 0.22 million ha in 2008-2009 for SW region and Bangladesh, respectively with yearly averages of 0.14 and 0.18 million ha for the region and country during the period 1999-2009 (Table 2).

| Year         | Region  | SP Cultivated Area (ha) | Percent |
|--------------|---------|--------------------------|---------|
|              | Khulna  | Bagerhat                 | Satkhira| SW region | Bangladesh | Share of SW |
| 1999-2000    | 29,551  | 47,710                   | 29,544  | 106,805    | 141,353    | 75.56%      |
| 2008-2009    | 51,921  | 59,424                   | 52,357  | 163,702    | 217,877    | 75.13%      |
| Yearly Average | 40,736  | 53,567                   | 40,950  | 135,253    | 179,615    | 75.35%      |
| Yearly Change| 6.46%   | 2.47%                    | 6.56%   | 4.86%      | 4.92%      | -           |

Source: BBS (2007 and 2011) and DOF (2011).

However, a mismatch is observed among the data regarding SP cultivated area reported in some other literatures with the BBS and DOF dataset. Most of the available literatures reported country level data and the reporting year varies significantly across the studies (Table 3). Therefore, this study attempts to generate a representative dataset on SP cultivated area using all of the available information.

Table 3 demonstrates a divergent scenario of SP cultivated area in Bangladesh. The reporting years widely vary among the cited sources of Table 3. Similarly, a divergent scenario is observed regarding the share of SW region in total shrimp cultivated area of Bangladesh. For example, Nupur (2010) states that about 80 percent of the shrimp farming areas are situated in the south-west region of Bangladesh, while the rest are in the south-east part of the country. However, the BBS dataset provides more specific information: the SW region comprises 75.35 percent of total SP cultivated area of the country during 1999-2009. Some available literatures state that the shrimp cultivating area of Bangladesh grows at around 10-20 percent per annum (Ahmed *et al.*, 2008; Huntington, 2003; Khatun, 2004; and Williams & Khan, 2001). However, Khatun (2004) talks only about *bagda*, Ahmed *et al.* (2008) refer to *gulda* only and Huntington (2003) and Williams & Khan (2001) consider both *bagda* and *gulda*. All of these growth related information seem to be approximate figures.

Moreover, none of them describes the growth in the SW region. In contrast, the BBS dataset reports 4.86 percent and 4.92 percent annual compound growth rate of SP cultivated area for the SW region and Bangladesh, respectively during 1999-2009. Therefore, this study
proceeds with this BBS information regarding the share of SW region and growth for calculating the SP cultivated area for the SW region and Bangladesh over the time period.

Table 3: Shrimp and prawn (SP) cultivated area in various years

| Serial No. | Source                          | Reporting Year | SP Cultivated Area (ha) |
|------------|---------------------------------|----------------|-------------------------|
|            |                                 |                | SW region    | Bangladesh            |
| 1          | MPO (1986)                      | 1983           | -           | 51,000                |
| 2          | Alauddin & Hamid (1999)         | 1983           | -           | 51,000                |
| 3          | Rosenberry (1995)               | 1994           | -           | 134,000               |
| 4          | DOF (1994)                      | 1994           | -           | 134,000               |
| 5          | Barraclough & Finger-Stich (1996)| 1996           | -           | 110,000               |
| 6          | NACA (2002)                     | 1996           | -           | 140,000               |
| 7          | Raux & Bailly (2002)            | 1997           | -           | 140,000               |
| 8          | DTS (2006)                      | 2003           | -           | 203,071               |
| 9          | Sarwar (2005)                   | 2004           | 115,900     | -                     |
| 10         | Khatun (2004)                   | 2004           | -           | 197,687               |
| 11         | ATDP II (2005)                  | 2005           | -           | 200,000               |
| 12         | Nupur (2010)                    | 2008           | -           | 217,887               |

Source: Authors’ compilation based on Alauddin & Hamid (1999), ATDP II (2005), Barraclough & Finger-Stich (1996), DOF (1994), DTS (2006), Khatun (2004), MPO (1986), Nupur (2010), Raux & Bailly (2002), Rosenberry (1995), Sarwar (2005), and NACA (2002).

Table 4: Shrimp and prawn (SP) cultivated area

| Year | SW Region (ha) | Bangladesh (ha) |
|------|----------------|-----------------|
|      | Minimum        | Average         | Maximum       | Minimum        | Average         | Maximum       |
| 1980 | 35,320         | 44,505          | 51,961        | 44,150         | 58,105          | 68,361        |
| 1985 | 42,305         | 56,197          | 65,873        | 56,147         | 73,893          | 86,936        |
| 1990 | 53,800         | 71,259          | 83,511        | 71,404         | 93,971          | 110,558       |
| 1995 | 68,419         | 90,364          | 105,937       | 90,805         | 119,506         | 140,599       |
| 2000 | 87,010         | 114,695         | 134,723       | 115,479        | 151,978         | 178,803       |
| 2005 | 110,653        | 145,640         | 171,330       | 146,858        | 193,265         | 227,388       |
| 2010 | 140,720        | 185,090         | 217,885       | 186,762        | 245,721         | 289,175       |
| 2011 | 147,650        | 194,186         | 228,615       | 195,960        | 257,810         | 303,417       |

Source: Authors’ compilation based on Ahmed et al. (2008), Alauddin & Hamid (1999), ATDP II (2005), Barraclough & Finger-Stich (1996), BBS (2007 and 2011), DOF (1994 and 2011), DTS (2006), Huntington (2003), Khatun (2004), MPO (1986), NACA (2002), Nupur (2010), Raux & Bailly (2002), Rosenberry (1995), Sarwar (2005), and Williams & Khan (2001).

Based on the BBS dataset regarding the SW region’s share and expansion of SP cultivated area, this study attempts to extrapolate the information of Table 3 for both SW region and Bangladesh during period 1980 to 2011. It assumes that the share and growth
information is true for the whole period. After extrapolating data of each of the reported studies in Table 3 for both SW region and Bangladesh separately for the period 1980-2011, it calculates year-wise simple averages to confine into a specific number for each year. Side-by-side, this study reports the year-wise minimum and maximum values to understand at least a range value of the SP cultivated area, if the calculated average value fails to represent the true scenario. The calculated results are reported in Table A1 of Annex and Table 4. According to the extrapolation based calculations, the calculated SP cultivation area in the SW region of Bangladesh is 0.19 million ha with 0.15 million ha minimum and 0.23 million ha maximum values for the year 2011. Similarly, the calculated SP cultivation area in Bangladesh is 0.26 million ha with 0.20 million ha minimum and 0.30 million ha maximum values for the year 2011.

**SP production**

This study uses six approaches, developed by the authors, to quantify the production of SP. The available information regarding production data is not well-organized and mismatches are found for the same variable cited in different sources. For example, some studies report total production in ‘kg per year’ while some others report production in ‘kg per ha’. Some studies consider both bagda and gelda together, while some others consider these two separately in reporting production data. Moreover, some studies report production data on the basis of production methods, such as, extensive, semi-intensive and intensive farming approaches. In reporting shrimp type-wise or method-wise production data, again, some sources report production in ‘kg per ha’ while some others report ‘Tk per ha’. Consequently, the logical calculation from the approaches generates divergent results and there is no consensus yet about which one best fits to the real scenario.

**Table 5: Shrimp and prawn (SP) production: Approach 1**

| Item                   | Unit       | Symbol | Minimum     | Average     | Maximum     |
|------------------------|------------|--------|-------------|-------------|-------------|
| Production (Bangladesh)| kg/year    | A      | 21,000,000  | 46,686,487  | 70,722,406  |
| Production (SW region) | kg/year    | B=A*0.75 | 15,822,875 | 35,176,878  | 53,287,228  |
| Price                  | Tk/kg      | C      | 629         | 760         | 953         |
| Production (SW region) | Million Tk/year | D=B*C/1 million | 9,949 | 26,744 | 50,766 |
| Production (SW region) | Million US$/year | E=D/80 | 124.37 | 334.30 | 634.58 |

N.B.: The minimum, average and maximum production (in kg/year) of SP in Bangladesh are reported in ‘A’. This study uses the information of BBS (2011), Huntington (2003), Raux & Bailly (2002), DTS (2006) and NACA (2002) to find production data of Bangladesh. Taking the BBS information regarding share of SW region in Bangladesh, it calculates the production (kg/year) of SP in SW region (‘B’). Then, it uses the information of DTS (2006) and Hasanuzzaman et al. (2011) for price of shrimp and corresponding minimum, average and maximum values are reported in ‘C’. Finally, it assumes 1 US$=Tk 80 to calculate SP production in the SW region of Bangladesh for year 2011 (‘E’).

Source: Authors’ compilation based on BBS (2007 and 2011), Hasanuzzaman et al. (2011), Huntington (2003), Raux and Bailly (2002), DTS (2006), and NACA (2002).
Approach 1 uses the information provided by BBS (2011), Huntington (2003), Raux & Bailly (2002), DTS (2006) and NACA (2002) to calculate shrimp production in Bangladesh. Taking the BBS information regarding the share of SW region in Bangladesh, it calculates the production (in kg/year) of SP in SW region. Then, it uses the information of DTS (2006) and Hasanuzzaman et al. (2011) for price of shrimp and corresponding minimum, average and maximum values are calculated. Finally, it assumes 1 US$=Tk 80 to calculate SP production in the SW region of Bangladesh for the year 2011. According to this approach, the average SP production in SW region of Bangladesh is 334 million US$ with 124 million US$ minimum and 635 million US$ maximum values for the year 2011 (Table 5).

Approach 2 uses the information of minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh from Muir (2003), Rahman (1999) and Raux & Bailly (2002) for getting per unit production (in kg/ha/year) data. Then, it calculates the production (in kg/year) of SP in SW region. It uses the information of DTS (2006) and Hasanuzzaman et al. (2011) for price of shrimp and corresponding minimum, average and maximum values are calculated. Finally, it calculates SP production in the SW region of Bangladesh for the year 2011. The calculation results reveal that the average SP production in SW region of Bangladesh is 475 million US$ with 232 million US$ minimum and 915 million US$ maximum values for the year 2011 (Table 6).

Table 6: Shrimp and prawn (SP) production: Approach 2

| Item                        | Unit   | Symbol | Minimum | Average | Maximum |
|-----------------------------|--------|--------|---------|---------|---------|
| Area (SW region)            | ha     | A      | 147,650 | 194,186 | 228,615 |
| Production (SW region)      | kg/ha/year | B | 200     | 257     | 336     |
| Production (SW region)      | kg/year | C=A*B  | 29,530,047 | 49,954,251 | 76,814,745 |
| Price                       | Tk/kg  | D      | 629     | 760     | 953     |
| Production (SW region)      | Million Tk/year | E=C*D/1 million | 18,568 | 37,979 | 73,181 |
| Production (SW region)      | Million US$/year | F=E/80 | 232.11  | 474.74  | 914.76  |

N.B.: The minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh are reported in ‘A’. This study uses the information of Muir (2003), Rahman (1999) and Raux & Bailly (2002) for getting per unit production (in kg/ha/year) data (‘B’). Then, it calculates the production (in kg/year) of SP in SW region (‘C’). It uses the information of DTS (2006) and Hasanuzzaman et al. (2011) for price of shrimp and corresponding minimum, average and maximum values are reported in ‘D’. Finally, it assumes 1 US$=Tk 80 to calculate SP production in the SW region of Bangladesh for year 2011 (‘F’).

Source: Authors’ compilation based on Hasanuzzaman et al. (2011), Muir (2003), Rahman (1999), and Raux and Bailly (2002).

The third approach also uses the minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh from Huntington (2003) to divide the cultivated area under bagda and galda. Then, it uses the information provided by Aftabuzzaman (2004),
DTS (2006), Huntington (2003) and Khatun (2004) to get per unit bagda and galda production (in kg/ha/year). It also uses the information of DTS (2006) and Hasanuzzaman et al. (2011) for price of shrimp and corresponding minimum, average and maximum values are calculated. Finally, it calculates SP production for the year 2011. Table 7 illustrates that the average SP production in SW region of Bangladesh is 439 million US$ with 211 million US$ minimum and 800 million US$ maximum values for the year 2011 (Table 7).

Table 7: Shrimp and prawn (SP) production: Approach 3

| Item                        | Unit  | Symbol | Minimum | Average | Maximum |
|-----------------------------|-------|--------|---------|---------|---------|
| Area (SW region)            | ha    | A      | 147,650 | 194,186 | 228,615 |
| Bagda Area (SW region)      | ha    | B      | 112,214 | 147,581 | 173,748 |
| Galda Area (SW region)      | ha    | C      | 35,436  | 46,605  | 54,868  |
| Bagda Production            | kg/ha/year | D    | 133     | 179     | 230     |
| Galda Production            | kg/ha/year | E    | 336     | 426     | 496     |
| Bagda Production (SW region)| kg/year | F=B*D | 14,924,486 | 26,380,117 | 39,961,957 |
| Galda Production (SW region)| kg/year | G=C*E | 11,906,515 | 19,851,091 | 27,214,367 |
| Price                       | Tk/kg | H      | 629     | 760     | 953     |
| Bagda Production (SW region)| Million US$/year | I=F*H/80/1 million | 117 | 251 | 476 |
| Galda Production (SW region)| Million US$/year | J=G*H/80/1 million | 94 | 189 | 324 |
| Production                  | Million US$/year | K=I+J | 210.89 | 439.36 | 799.98 |

N.B.: The minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh are reported in ‘A’. This study uses the information of Huntington (2003) to divide the cultivated area under bagda and galda (‘B & C’). Then, it uses the information of Aftabuzzaman (2004), DTS (2006), Huntington (2003) and Khatun (2004) to get per unit bagda and galda production (in kg/ha/year) (‘D & E’). It uses the information of DTS (2006) and Hasanuzzaman et al. (2011) for price of shrimp and corresponding minimum, average and maximum values are reported in ‘H’. Finally, it assumes 1 US$=Tk 80 to calculate SP production in the SW region of Bangladesh for year 2011 (‘K’).

Source: Authors’ compilation based on Aftabuzzaman (2004), Hasanuzzaman et al. (2011), Huntington (2003), Khatun (2004), and DTS (2006).

Approach 4 starts with the information of minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh from Huntington (2003) to divide the cultivated area under bagda and galda. Then, it uses DTS (2006) data to get per unit bagda and galda production (in US$/ha). Finally, it calculates SP production in the SW region of Bangladesh for the year 2011. Table 8 illustrates that the average SP production in SW region of Bangladesh is 322 million US$ with 245 million US$ minimum and 379 million US$ maximum values for the year 2011 (Table 8).
Table 8: Shrimp and prawn (SP) production: Approach 4

| Item                          | Unit    | Symbol | Minimum | Average | Maximum |
|-------------------------------|---------|--------|---------|---------|---------|
| Bagda Area (SW region)        | ha      | A      | 147,650 | 194,186 | 228,615 |
| Galda Area (SW region)        | ha      | B      | 112,214 | 147,581 | 173,748 |
| Bagda Production (SW region)  | US$/ha  | D      | 1,027   | 1,027   | 1,027   |
| Galda Production (SW region)  | US$/ha  | E      | 3,648   | 3,648   | 3,648   |
| Production (SW region)        | Million US$/year | F=B*D/1 million | 115 | 152 | 179 |
|                               | Million US$/year | G=C*E/1 million | 129 | 170 | 200 |

N.B.: The minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh are reported in ‘A’. This study uses the information of Huntington (2003) to divide the cultivated area under bagda and galda (‘B & C’). Then, it uses the information of DTS (2006) data to get per unit bagda and galda production (in US$/ ha) (‘D & E’). Finally, it calculates SP production in the SW region of Bangladesh for year 2011 (‘H’).

Source: Authors’ compilation based on Huntington (2003), and DTS (2006).

The fifth approach also uses the minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh from Paul & Vogl (2011) and NACA (2002) to divide the cultivated area under Extensive, Semi-intensive and Intensive methods. Then, it uses information of Bhattacharya et al. (1999), Gammage et al. (2005), Haque (2004), Mazid (1994), Rosenberry (1995) and DTS (2006) to get per unit production (in kg/ha/year) data for different methods. It also uses the information of DTS (2006) and Hasanuzzaman et al. (2011) for price of shrimp and corresponding minimum, average and maximum values are calculated. Finally, it calculates SP production in the SW region of Bangladesh for the year 2011. According to this approach, the average SP production in SW region of Bangladesh is 451 million US$ with 85 million US$ minimum and 936 million US$ maximum values for the year 2011 (Table 9).

Approach 6 also starts with the information of minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh from Paul & Vogl (2011) and NACA (2002) to divide the cultivated area under Extensive, Semi-intensive and Intensive methods. Then, it uses the information of Gammage et al. (2005), Haque (2004) and DTS (2006) to get per unit production (in Tk/ha/year) data for different methods. Finally, it calculates SP production in the SW region of Bangladesh for the year 2011. Table 10 illustrates that the average SP production in SW region of Bangladesh is 191 million US$ with 36 million US$ minimum and 339 million US$ maximum values for the year 2011 (Table 10).
Table 9: Shrimp and prawn (SP) production: Approach 5

| Item                        | Unit | Symbol | Minimum | Average | Maximum |
|-----------------------------|------|--------|---------|---------|---------|
| Area (SW region)            | ha   | A      | 147,650 | 194,186 | 228,615 |
| Ext. Area (SW region)       | ha   | B      | 103,355 | 155,348 | 205,754 |
| Semi-Int. Area (SW region)  | ha   | C      | 14,765  | 33,982  | 5,715   |
| Int. Area (SW region)       | ha   | D      | -       | 4,855   | 11,431  |
| Ext. Production             | kg/ha/year | E  | 100     | 238     | 350     |
| Semi-Int. Production        | kg/ha/year | F  | 250     | 617     | 1000    |
| Int. Production             | kg/ha/year | G  | 1000    | 1500    | 2000    |
| Ext. Production (SW region) | kg/year | H=B*E | 10,335,516 | 36,895,268 | 72,013,823 |
| Semi-Int. Production (SW)   | kg/year | I=C*F | 3,691,256 | 20,955,865 | 5,715,383 |
| Int. Production (SW region) | kg/year | J=D*G | -       | 7,281,961 | 22,861,531 |
| Price                       | Tk/kg | K     | 629     | 760     | 953     |
| Ext. Production (SW region) | Million US$/year | L=H*K/80/1 million | 81 | 351 | 858 |
| Semi-Int. Production (SW)   | Million US$/year | M=I*K/80/1 million | 4 | 92 | 61 |
| Int. Production (SW region) | Million US$/year | N=J*K/80/1 million | - | 8 | 18 |
| Production (SW region)      | Million US$/year | O=L+M+N | 84.99 | 450.84 | 936.37 |

N.B.: The minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh are reported in ‘A’. This study uses the information of Paul & Vogl (2011) and NACA (2002) to divide the cultivated area under Extensive, Semi-intensive and Intensive methods (‘B, C & D’). Then, it uses the information of Bhattacharya et al. (1999), Gammage et al. (2005), Haque (2004), Mazid (1994), Rosenberry (1995) and DTS (2006) to get per unit production (in kg/ha/year) data for different methods (‘E, F & G’). It uses the information of DTS (2006) and Hasannagaman et al. (2011) for price of shrimp and corresponding minimum, average and maximum values are reported in ‘K’. Finally, it assumes 1 US$=Tk 80 to calculate SP production in the SW region of Bangladesh for year 2011 (‘O’).

Source: Authors’ compilation based on Bhattacharya et al. (1999), Gammage et al. (2005), Haque (2004), Mazid (1994), Paul and Vogl (2011), Rosenberry (1995), DTS (2006), and NACA (2002).
Table 10: Shrimp and prawn (SP) production: Approach 6

| Item                        | Unit       | Symbol | Minimum           | Average          | Maximum          |
|-----------------------------|------------|--------|-------------------|------------------|------------------|
| Area (SW region)            | ha         | A      | 147,650           | 194,186          | 228,615          |
| Ext. Area (SW region)       | ha         | B      | 103,355           | 155,348          | 205,754          |
| Semi-Int. Area (SW region)  | ha         | C      | 14,765            | 33,982           | 5,715            |
| Int. Area (SW region)       | ha         | D      | 0                 | 4855             | 11431            |
| Ext. Production (SW region) | Tk/ha/year | E      | 8,339             | 49,044           | 95,904           |
| Semi-Int. Production        | Tk/ha/year | F      | 136,280           | 153,515          | 170,749          |
| Int. Production             | Tk/ha/year | G      | 439,412           | 498,451          | 557,490          |
| Ext. Production (SW region) | Tk/year    | H=B*E  | 861,928,196       | 7,618,958,305    | 19,732,611,865   |
| Semi-Int. Production (SW)   | Tk/year    | I=C*F  | 2,012,178,092     | 5,216,813,166    | 975,898,716      |
| Int. Production (SW region) | Tk/year    | J=D*G  | -                 | 2,419,799,926    | 6,372,535,206    |
| Ext. Production (SW region) | Million US$/year | K=H/80/1 million | 11             | 95             | 247             |
| Semi-Int. Production (SW)   | Million US$/year | L=I/80/1 million | 25             | 65             | 12              |
| Int. Production (SW region) | Million US$/year | M=J/80/1 million | 0             | 30             | 80              |
| Production (SW region)      | Million US$/year | N=K+L+M | 35.93           | 190.69          | 338.51          |

N.B.: The minimum, average and maximum SP cultivated area (in ha) in the SW region of Bangladesh are reported in 'A'. This study uses the information of Paul & Vogl (2011) and NACA (2002) to divide the cultivated area under Extensive, Semi-intensive and Intensive methods ('B, C & D'). Then, it uses the information of Gammage et al. (2005), Haque (2004) and DTS (2006) to get per unit production (in Tk/ha/year) data for different methods ('E, F & G'). Finally, it assumes 1 US$=Tk 80 to calculate SP production in the SW region of Bangladesh for year 2011 ('N').

Source: Authors’ compilation based on Gammage et al. (2005), Haque (2004), Paul and Vogl (2011), DTS (2006), and NACA (2002).
Table 11: Shrimp and prawn (SP) production in Southwest Bangladesh

| Approach | Information used                        | Production in SW Region (Million US$ in 2011) |
|----------|----------------------------------------|-----------------------------------------------|
|          |                                        | Minimum | Average | Maximum |
| 1        | Kg/year and Tk/kg                      | 124.37  | 334.30  | 634.58  |
| 2        | Kg/ha/year and Tk/kg                   | 232.11  | 474.74  | 914.76  |
| 3        | Shrimp type-wise kg/ha/year and Tk/kg  | 210.89  | 439.36  | 799.98  |
| 4        | Shrimp type-wise kg/ha/year and Tk/ha  | 244.58  | 321.66  | 378.70  |
| 5        | Production method-wise kg/ha/year and Tk/kg | 84.99  | 450.84  | 936.37  |
| 6        | Production method-wise kg/ha/year and Tk/ha | 35.93  | 190.69  | 338.51  |
| Average  |                                        | **155.48** | **368.60** | **667.15** |

Source: Authors’ compilation based on Aftabuzzaman (2004), Ahmed et al. (2008), Alauddin & Hamid (1999), ATDP II (2005), Barraclough & Finger-Stich (1996), BBS (2007 & 2011), Bhattacharya et al. (1999), DOF (1994), DTS (2006), Gammage et al. (2005), Haque (2004), Hasanuzzaman et al. (2011), Huntington (2003), Khatun (2004), Mazid (1994), MPO (1986), Muir (2003), NACA (2002), Nupur (2010), Paul & Vogl (2011), Rahman (1999), Raux and Bailly (2002), Rosenberry (1995), Sarwar (2005), and Williams and Khan (2001).

The considered six approaches generate divergent results about SP production in the SW region of Bangladesh (Table 5-10). Therefore, this study takes a simple average to quantify SP production. The necessary adjustments are made to convert the results in present value of the year 2011. The corresponding minimum and maximum values are also reported to understand a range value of the SP production, if the calculated average value fails to represent the true scenario (Table 11). The study findings indicate that the minimum and maximum values of SP production in the SW region of Bangladesh are 155 and 667 million US$, respectively with an average value\(^2\) of 369 (±108) million US$ for the year 2011. Following similar methodology, the study finds that the minimum and maximum values of SP production in Bangladesh are 207 and 893 million US$, respectively with an average value of 497 million US$ for the year 2011.

Conclusion

Review of available literatures finds a significant variation in the available data on shrimp cultivated area and shrimp production in Bangladesh. Diversity in reporting time, units of measurement, cultivation method, shrimp type and covered areas are the major issues that generate the variation. Moreover, dissimilarity is found among data of different sources even though reporting time and other features are similar. Therefore, the authors attempt to

\(^2\)Value within parenthesis indicates standard deviation.

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generate a representative and updated dataset of shrimp and prawn (SP) area coverage and production in the south-west region of Bangladesh. The authors try to represent the area data in ha and production data in US$. Year 2011 is the reporting year for this study. BBS and DOF are the two main sources that are consulted in this study. However, some other sources are also considered to confine into a specific number for the variables under consideration. The authors use the concept of extrapolation in this study to fill the data gap, as found to be necessary.

The study finds that the calculated SP cultivated area in the south-west region of Bangladesh is 0.19 million ha with 0.15 million ha minimum and 0.23 million ha maximum values for the year 2011. Similarly, the calculated SP cultivated area in Bangladesh is 0.26 million ha with 0.20 million ha minimum and 0.30 million ha maximum values for the year 2011. The calculations of this study under six approaches generate a wider variation in SP production data ranging from 36 to 936 million US$ for the south-west region of Bangladesh. Considering the simple average of these six approaches, this study confines the production value to 369 (±108) million US$ with 155 million US$ minimum and 667 million US$ maximum values for the year 2011 in the region. Similarly, the study findings indicate that the minimum and maximum values of SP production in Bangladesh are 207 and 893 million US$, respectively with an average value of 497 million US$ for the country in the year 2011.

This study calculates the shrimp and prawn area coverage and production using secondary information. It also makes some crucial assumptions, if relevant information are not available. Therefore, the accuracy of the study findings depends on the validity of those information sources and assumptions. For the very reason, the results of this study need to be carefully interpreted. Since there is no consensus yet in the literature about the shrimp area coverage and production data, the findings of this study may be a benchmark for future studies on shrimp sector of Bangladesh.

Disclaimer
The views expressed in this paper are those of the authors and do not necessarily reflect the views and policies of the Asian Development Bank (ADB), its Board of Governors, or the governments they represent. ADB does not guarantee the accuracy of the data included in this paper, and accepts no responsibility for any consequence of their use.

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References
Abedin, J. and Kabir, K. 1999. Cost Benefits Analysis of Gher System under Khulna Areas before Project Intervention. A survey report prepared by greater options for local development through ‘aquaculture project’ of CARE-Bangladesh, Dhaka, Bangladesh
Abidin, J.; Sarker, G. and Hena, A. 1997. A Cost Benefit Analysis of Current Gher Farming System Practices in Bagerhat District. Paper presented at the CARE Bangladesh aquaculture workshop, BARD, Comilla, Bangladesh

Afatuzzaman, A. 2004. Organic Aquaculture. National Shrimp Farmer’s Association, Dhaka, Bangladesh

Ahmed, N.; Demaine, H. and Muir, J.F. 2008. Freshwater Prawn Farming in Bangladesh: History, Present Status and Future Prospects. *Aquaculture Research* 39(1): 806-819

Alauddin, M. and Hamid, M.A. 1999. Shrimp Culture in Bangladesh with Emphasis on Social and Economic Aspects. pp. 53-62. In: Smith, P.T. (ed.). *Towards Sustainable Shrimp Culture in Thailand and the Region*. Australian Centre for International Agricultural Research, Canberra, Australia

ATDP II, 2005. An Evaluation of the Bangladesh Agro-based Industries and Technology Development Project (ATDP II). Report submitted to United States Agency for International Development (USAID), Bangladesh

Barmon, B.K.; Chaudhury, M. and Munim, S.S. 2011. Value Chain and Marketing Channels of Shrimp/Prawn Sector of Gher Farming System in Bangladesh. *World Review of Business Research* 1(1): 10-24

Barracough, S. and Finger-Stich, A. 1996. Some Ecological and Social Implications of Commercial Shrimp Farming in Asia. United Nations Research Institute for Social Development (UNRISD) Discussion Paper 74

BBS, 2007. Statistical Yearbook of Bangladesh, 2006. Bangladesh Bureau of Statistics (BBS), Planning Division, Ministry of Planning, Government of People’s Republic of Bangladesh, Dhaka, Bangladesh

BBS, 2011. Statistical Yearbook of Bangladesh, 2010. Bangladesh Bureau of Statistics (BBS), Planning Division, Ministry of Planning, Government of People’s Republic of Bangladesh, Dhaka, Bangladesh

Bhattacharya, D.; Rahman, M. and Khatun, F.A. 1999. Environmental Consequences of Structural Adjustment: Towards Sustainable Shrimp Culture in Bangladesh. CPD Occasional Paper Series 2, Dhaka, Bangladesh

DOF, 1994. District-Wise Area and Number of Shrimp Farms. Department of Fisheries (DOF), Dhaka, Bangladesh

DOF, 2011. Fisheries Statistical Yearbook of Bangladesh 2008-2009. Department of Fisheries (DOF), Dhaka, Bangladesh

DTS, 2006. A Pro-Poor Analysis of the Shrimp Sector in Bangladesh. Report prepared by Development & Training Services, Inc. (DTS) for United States Agency for International Development (USAID) under Greater Access to Trade Expansion (GATE) Project, Dhaka, Bangladesh

Gammage, S.; Swanburg, K.; Khandkar, M.; Hassan, M.Z.; Zobair, M. and Muzareba, A.M. 2005. A Gendered Analysis of the Shrimp Sector in Bangladesh. Gender Access to Trade and Expansion, USAID, Dhaka, Bangladesh
Haque, A.K.E. 2004. Sanitary and Phyto-Sanitary Barriers to Trade and its Impact on the Environment - The Case of Shrimp Farming in Bangladesh. Trade Knowledge Network (TKN) Paper, International Institute for Sustainable Development, Manitoba, Canada

Hasanuzzaman, A.F.M., Rahman, M.A. and Islam, S.S. 2011. Practice and Economics of Freshwater Prawn Farming in Seasonally Saline Rice Field in Bangladesh. Mesopot. J. Mar. Sci. 26(1): 69-78

Huntington, T. 2003. Environmental Issues in Shrimp Farming in Bangladesh. Paper prepared for the Fourth Fisheries Project, Aquatic Resources Development, Management & Conservation Studies (ARDMCS), Dhaka, Bangladesh

Khatun, F. 2004. Fish Trade Liberalization in Bangladesh: Implications of SPS Measures and Eco-Labelling for the Export-Oriented Shrimp Sector – Policy Research – Implications of Liberalization of Fish Trade for Developing Countries. Project PR 26109, Food and Agriculture Organization (FAO) of the United Nations, Rome

Masum, S.J.H. 2008. Working Together for Responsible & Eco-friendly Shrimp Farming in Bangladesh - Exploring Corporate Environmental Responsibility (CER) & Corporate Social Responsibility (CSR) in the context of Commercial Shrimp Sector in Bangladesh. Coastal Development Partnership (CDP), Khulna, Bangladesh

Mazid, M.A. 1994. Environmental Issues and Aquaculture Development in Bangladesh. Country Paper presented at the Final Workshop, Food and Agriculture Organization (FAO) of the United Nations Regional Office for Asia and the Pacific

MPO, 1986. Final Report (Volumes I–III). Master Plant Organization (MPO), Dhaka, Bangladesh

Muir, J.F. 2003. The Future for Fisheries: Economic Performance. Fisheries Sector Review and Future Development Study, Commissioned with the association of the World Bank, DANIDA, USAID, FAO, DFID with the cooperation of the Bangladesh Ministry of Fisheries and Livestock and the Department of Fisheries, Dhaka, Bangladesh

NACA, 2002. Shrimp Farming and the Environment: Can Shrimp Farming Be Undertaken Sustainably?. Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand

Nupur, J.M. 2010. Problems and Prospects of Shrimp Farming in Bangladesh. American International University-Bangladesh (AIUB) Business and Economics Working Paper Series, No 2010-05, Dhaka, Bangladesh

Paul, B.G. and Vogl, C.R. 2011. Impacts of Shrimp Farming in Bangladesh: Challenges and Alternatives. Ocean & Coastal Management 54(3): 201-211.

Pillay, T.V.R. 1992. Aquaculture and Environment. Fishing News Books, pp. 108-115

PRICE, 2010. Bangladesh Poverty Reduction Increasing the Competitiveness of Enterprises (PRICE) Quarterly Report: October - December 2010

Primavera, J.H. 1991. Intensive Prawn Farming in the Philippines: Ecological, Social and Economic Implications. Ambio 20(1): 28-33.
Rahman, M.M. 1999. Problem and Prospectus of Prawn Farming in Coastal Area. In: *Fishery Week*, 16-22 September, 1999, Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh: 54-60

Rajalakshmi, N. 2002. *Conflicts of Water and Soil resources over Aquaculture Production in Coastal Tamilnadu and Pondicherry.* EERC Working Paper Series: MES-2

Raux, P. and Bailly, D. 2002. *Literature Review on World Shrimp Farming.* Individual Partner Report for the Project: Policy Research for Sustainable Shrimp Farming in Asia – A Comparative Analysis of Bangladesh, India, Thailand, and Vietnam with Particular Reference to Institutional and Socio-Economic Aspects. European Commission INCODEV Project No. IC4-2001-10042, CEMARE University of Portsmouth, UK and CEDEM, Brest, France

Rosenberry, B. (ed.) 1995. *World Shrimp Farming 1995: Annual Report.* Shrimp News International, San Diego

Sarwar, M.G.M. 2005. *Impacts of Sea Level Rise on the Coastal Zone of Bangladesh.* Master’s Thesis, Lund University International Masters Programme in Environmental Science, Sweden

UNEP, 1999. *Trade Liberalisation and the Environment – Lessons Learned from Bangladesh, Chile, India, Philippines, Romania and Uganda: A Synthesis Report.* United Nations Environment Programme (UNEP), UNEP/99/7, United Nations, New York and Geneva

Williams, D. and Khan, N. 2001. *Freshwater Prawn Gher Farming Systems: Indigenous Technology Developed in South West Bangladesh.* CARE GOLDA Project, CARE Bangladesh, Dhaka, Bangladesh

**Annex**

Table A1: Shrimp and prawn (SP) cultivated area in southwest region and Bangladesh

| Year | SW Region (ha) | Bangladesh (ha) |
|------|----------------|-----------------|
|      | Minimum | Average | Maximum | Minimum | Average | Maximum |
| 1980 | 35,320   | 44,505   | 51,961   | 44,150   | 58,105   | 68,361   |
| 1981 | 37,060   | 46,670   | 54,486   | 46,325   | 60,966   | 71,727   |
| 1982 | 38,885   | 48,940   | 57,133   | 48,606   | 63,969   | 75,260   |
| 1983 | 38,427   | 51,105   | 59,909   | 51,000   | 67,119   | 78,966   |
| 1984 | 40,319   | 53,590   | 62,821   | 53,512   | 70,425   | 82,855   |
| 1985 | 42,305   | 56,197   | 65,873   | 56,147   | 73,893   | 86,936   |
| 1986 | 44,389   | 58,930   | 69,074   | 58,912   | 77,532   | 91,217   |
| 1987 | 46,575   | 61,796   | 72,431   | 61,814   | 81,351   | 95,710   |
| 1988 | 48,868   | 64,802   | 75,950   | 64,858   | 85,357   | 100,423  |
| 1989 | 51,275   | 67,954   | 79,641   | 68,052   | 89,561   | 105,369  |
| 1990 | 53,800   | 71,259   | 83,511   | 71,404   | 93,971   | 110,558  |
| 1991 | 56,450   | 74,725   | 87,569   | 74,920   | 98,599   | 116,003  |
| 1992 | 59,230   | 78,359   | 91,824   | 78,610   | 103,455  | 121,716  |
| Year | SW Region (ha) | Bangladesh (ha) |
|------|----------------|-----------------|
|      | Minimum | Average | Maximum | Minimum | Average | Maximum |
| 1993 | 62,147  | 82,171  | 96,286  | 82,481  | 108,550 | 127,710 |
| 1994 | 65,208  | 86,167  | 100,965 | 86,543  | 113,896 | 134,000 |
| 1995 | 68,419  | 90,364  | 105,937 | 90,805  | 119,506 | 140,599 |
| 1996 | 71,789  | 94,766  | 111,155 | 95,278  | 125,391 | 147,524 |
| 1997 | 75,324  | 99,393  | 116,629 | 99,970  | 131,566 | 154,789 |
| 1998 | 79,034  | 104,252 | 122,373 | 104,893 | 138,046 | 162,412 |
| 1999 | 82,926  | 109,349 | 128,400 | 110,059 | 144,845 | 170,411 |
| 2000 | 87,010  | 114,695 | 134,723 | 115,479 | 151,978 | 178,803 |
| 2001 | 91,295  | 120,303 | 141,358 | 121,167 | 159,463 | 187,609 |
| 2002 | 95,792  | 126,184 | 148,320 | 127,134 | 167,316 | 196,849 |
| 2003 | 100,509 | 132,354 | 155,624 | 133,395 | 175,556 | 206,543 |
| 2004 | 105,459 | 138,833 | 163,289 | 139,965 | 184,202 | 216,715 |
| 2005 | 110,653 | 145,640 | 171,330 | 146,858 | 193,265 | 227,388 |
| 2006 | 116,103 | 152,788 | 179,768 | 154,090 | 202,773 | 238,587 |
| 2007 | 121,820 | 160,288 | 188,622 | 161,679 | 212,749 | 250,337 |
| 2008 | 127,820 | 168,156 | 197,911 | 169,642 | 223,217 | 262,666 |
| 2009 | 134,115 | 176,420 | 207,658 | 177,996 | 234,199 | 275,602 |
| 2010 | 140,720 | 185,090 | 217,885 | 186,762 | 245,721 | 289,175 |
| 2011 | 147,650 | 194,186 | 228,615 | 195,960 | 257,810 | 303,417 |

Source: Authors’ compilation based on Ahmed et al. (2008), Alauddin & Hamid (1999), ATDP II (2005), Barraclough & Finger-Stich (1996), BBS (2007 and 2011), DOF (1994 and 2011), DTS (2006), Huntington (2003), Khatun (2004), MPO (1986), NACA (2002), Nupur (2010), Raux & Bailly (2002), Rosenberry (1995), Sarwar (2005), and Williams & Khan (2001).