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Aquaculture production of exportable species in West Bengal: Decomposition models

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Abstract

Indian aquaculture sector plays a significant position in the socio-economic improvement of the country, in view of its potential contribution to national income, nutritional security, employment opportunities and export earnings. The study has estimate the growth performance and decomposition analysis in area, production and productivity in aquaculture production of new exportable species in West Bengal during the period 2013-14 to 2020-21. The highest annual growth rate was found Sea Bass (91.96%) in production followed by Pangasius (87.72%) in Productivity and Sea Bass (78.12%) in area respectively. The significant development in area of culture in Tilapia by 41.44% in study period. The decomposition analysis of growth suggests that for Pangasius and Crab culture Productivity effect is the major source of growth in study period and Sea Bass and Tilapia for which area effect was the major source. That is source of output growth for Pangasius and Crab was the productivity effect; for Sea Bass and Tilapia, the growth source was the area effect. The change in mean productivity was primary source of growth in Pangasius and crab. Similarly, the change in mean area was major source of growth in Sea Bass and Tilapia in West Bengal during study period. The change in productivity variance contributed maximum to change in variance of crab production in all other aquaculture species, followed by Interaction between change in mean area and productivity variance.

Keywords: Decomposition models, growth, aquaculture, production, area

1. Introduction

Export oriented aquaculture production, showed a remarkable increase during the year 2020-21 with a production of 8, 66, 600 MT, which is significantly high compared to a production 7, 66,809 MT of year 2019-20. The increase in production solely depends on the increase in the production of Pacific White leg shrimp (*Litopenaeus vannamei*). Mangrove Crab, Sea bass, Tilapia (GIFT) and Pangasius species are commercially cultured fisheries production in different regions. During the year 2020-21 the total production of 1,96,816.455 MT of diversified species, which included 4,519.05 MT of Mangrove Crab, 3,625.775 MT of Sea bass, 6,473.33 MT of Tilapia, and 1,82,198.30 MT of Pangasius (Anon, 2021) [2]. Capture fisheries production has levelled off and is no longer considered capable of sustaining the supply of fisheries products needed to meet the growing global demand (Subasinghe, Soto & Jia, 2009) [30]. Mud crab farming has the potential to support vulnerable coastal population thereby strengthening its resilience, flexibility, and adaptability in the dynamical coastal climate of Sundarban (Rahman *et al*., 2017) [23]. Mud crabs fetch a good market value in both domestic and also serve as an ideal species for live export to other countries too. The market value can range from 8 to 25 USD depending on size and season (Lalramchhani *et al*, 2019) [13]. Tilapia is the common name for several species of cichlid fish inhabiting freshwater streams, ponds, rivers and lakes and less commonly in brackish water. Tilapia is the maximum diversified culturally fish species within the world, has got new heights of production in current times. It takes a vital role in the fish farming business for great demand and value of this species in the local and international market (Ghorai, 2021) [8]. Tilapia fish can usually survive our environment in 12 °C to 40 °C temperature and grow well in 16 °C to 35 °C temperature. Naturally male tilapia grows rapidly than female. The most common species of tilapia used for tank culture in the West Bengal are Tilapia nilotica, Tilapia aureaus, Tilapia mossambicus and hybrids between these species or strains. But the study is confined to only Tilapia nilotica or Nile tilapia (*Oreochromis niloticus*) because of its highest growth rate and strong under tropical region, diseases are minus and produce for twice a year. Intensive tank culture offers some advantages over the use of ponds (Dennis *et al*., 2009) [4].

Pangasius (*Pangasianodon hypophthalmus*) an exotic species has been introduced into India possibly during 1997 clandestinely via Bangladesh and adopted for culture in the state of West Bengal. Because of its remarkable growth rate (almost one kg in 90 days), there has been much enthusiasm among fish breeders and farmers particularly in West Bengal and Andhra Pradesh for its culture and propagation (Lakra and Singh, 2010) [12]. Fish seed production segment in West Bengal played a pivotal role in the expansion of Pangasius farming in Andhra Pradesh. Pangasius monoculture was found to be profitable in comparison to polyculture with carps and other fishes (Seshagiri *et al*., 2021; Swapna *et al*., 2022) [27, 31]. Pangas is one of the fastest expanding fish species and has great potential for production and export growth. However, production variability exists from farm to farm and location to location, which indicates that production risk may be a problem in pangas farming. Research on production risk is therefore of great importance, especially for small-scale farming systems in developing countries, where farmers are more vulnerable to risk (Akhtaruzzaman, Atle & Kristin, 2018) [1]. The major determinants of Pangasisus production were feed, seed, area, experience in Pangasius culture and days of culture (Pankajkumar, Nalini & Biradar, 2019) [21]. Sea bass is one of the most preferred fish. CIBA has successfully bred the species for the first time in the country in 1997. Seed production technology has been perfected and year round breeding of the species has been achieved. The technology for nursery rearing 32 Freshwater Aquaculture in India for the production of fingerlings have been developed and demonstrated which has been taken up by small farmers and WSHGs. Technology for the culture of sea bass in ponds has been standardized with slow sinking feed developed by CIBA. The culture is followed in three stages – Nursery, Pre grow-out and Grow-out. The technology has been demonstrated in six coastal states in farmers' ponds and there is a wide spread demand for the seed and feed. The major issue in the adoption of sea bass culture is the low profit margin in comparison to shrimp culture (Ravichandran, 2014) [25]. West Bengal is one of the largest districts having a population of 69, 06,689, of which 58, 20,469 (84%) belongs to rural areas. Being a coastal district, majority of its rural population earn their livelihood from fisheries. Below Poverty Level (BPL) families constitute 37.21% of the total population of the district (Dana, Ghosh & Bandyopadhyay, 2015) [3]. Coastal West Bengal has a coast line of 157km., inshore area 777sq. km (up to 10 fathoms), offshore area 1813 sq. km. (from 10 to 40 fathoms) and shelf area 17,094sq. km. (up to 100 fathoms). It comprises of three districts covering Digha-Rasulpur coast in East Midnapore district and Sundarban coast in North 24-Parganas and South 24-Parganas districts. In these areas, crab farming can be practiced by leasing out the coastal inshore areas, estuarine mudflats and in suitable tidal channels for culturing of crabs. In addition to above, Aquacul durable brackish water systems (4,20,000 ha) and freshwater marshes (beels) and oxbow lakes (baors) (80,000ha) may also be looked into for the purpose of culturing freshwater inhabiting grapsid, varuna, portend and pot amid species (Roy and Nandi, 2019) [26]. Fishery turns itself to a profitable business due to increasing innovations and modern technology. In spite of that crab farming in West Bengal has always been kept in the dark. In the recent years, there is a rapid growth of crab markets in West Bengal. The coastal and estuarine waters of West Bengal give a large amount of crabs which can be exported. But the crab fishery in West Bengal moving towards the intensive farming from the traditional practices (Dana, Ghosh & Bandyopadhyay, 2015; Pavel *et al*., 2021) [3, 22]. Striped catfish (*Pangasianodon hypophthalmus*) was introduced into Andhra Pradesh by seed sellers from West Bengal, India as early as 1995 (Ramakrishna, Ship ton & Hassan, 2013; Singh and Lakra, 2012) [24, 28]. The major portions of these Parganas districts are covered by Indian Sundarbans, which is a mangrove dominated deltaic complex at the apex of Bay of Bengal (Mitra *et al*., 2004) [17].

In this context, this study was carried out to appraise the growth and Decomposition analysis models occurred in the area, production and productivity of aquaculture in West Bengal for the period of last eight years from 2013-14 to 2020-21.

2. Material and Methods

The study is based on secondary data collected from published sources various Annual reports on Marine Product Export Development Authority website for a period of eight years (2013-14 to 2020-21). The study used time series data on the area, production and productivity of selected aquaculture production of new exportable species for a period of 2013-14 to 2020-21. To fulfil the specific objective of the study based on the nature and extent of availability of data, the following techniques were adopted.

2.1 Growth Rates Analysis

The speed of aqua cultural development of a region can be ascertained through measuring growth in area, production and productivity of crops in the West Bengal region. In the present study, compound growth rates of area, production and productivity for the selected cultures for study period were estimated to study the growth in area, production and productivity of these cultures.

However compound growth rates were used for the study. Compound growth rates were estimated with the following exponential model.

$$Y = Ab^t \qquad (1)$$

$$\text{Log } Y = \log a + t \log b$$

$$CGR = (\text{Antilog } b-1) \times 100$$

Where, CGR = Compound growth rate

t = Time period in year y =Area/ production / productivity

A & b =Regression parameters.

2.2 Decomposition and Output Growth Analysis

2.2.1 Decomposition Analysis Model (Minhas and Vaidya Nathan, 1965) [15]

This model was used to measure the relative contribution of area and productivity to the total output of the culture production. In this method variables used as Ao, Po and Yo indicate the respective area (Ha), production (Mt) and yield (Mt/ha/year) or productivity in base year while another set of variables An, Pn and Yn indicate the respective variables in n^{th} year.

$$P_o = A_o \times Y_o \text{ and}$$

$$P_n = A_n \times Y_n \qquad (2)$$

The variation in production, area and productivity are calculated using following functions;

$P_n - P_o = \Delta P$

$A_n - A_o = \Delta A$ and

$Y_n - Y_o = \Delta Y$ (3)

For equation (2) and (3) we can write

$P_0 + \Delta P = (A_0 + \Delta A)(Y_0 + \Delta Y)$

Hence

$$P = \frac{A_o \Delta Y}{\Delta P} \times 100 + \frac{Y_o \Delta A}{\Delta P} \times 100 + \frac{\Delta Y \Delta A}{\Delta P} \times 100$$

Production = yield effect + area effect + interaction effect
Thus, the total change in production is decomposed into three components *viz*. productivity effect, area effect and the interaction effect due to change in productivity and area.

In estimating the change in average production and change in the variance of production with respect to between regimes and the overall period, Hazel's (1982) [36] decomposition model, which decomposed the sources of change in the average of production and change in production variance into four (4) and ten (10) components as cited by Umar *et al*. (2019) [34] was used. Decomposition analysis of change in production assesses the quantum of increase or otherwise of production in year 'n' over the base year that results from a change in the area, productivity or their interaction.

2.2.3 Changes in average production: It is caused by changes in the covariance between area and productivity and changes in mean area and mean productivity. The model is shown in Equations 4 and 5 and components of change in the average production are shown in Table 1.

2.2.4 Change in variance decomposition: The source of instability is caused by ten factors and the model is shown as Equation 6 and the component of variance decomposition is shown in Table 2.

$$E(P) = \bar{A}\bar{Y} + COV(A,Y) \quad (4)$$

2.2.2 Hazel's Decomposition Analysis Model

$$\Delta E(P) = E(P_2) - E(P_1) = \bar{A}_1 \Delta \bar{Y} + Y_1 \Delta \bar{A} + \Delta \bar{A} \Delta \bar{Y} + \Delta COV(A,Y) \quad (5)$$

$$V(P) = \bar{A}^2 . V(Y) + \bar{Y}^2 . V(A) + 2\bar{A}\bar{Y}COV(A,Y) - COV(A,Y)^2 + R \quad (6)$$

Table 1: Components of Change in Average Production

S.No	Source of Change	Symbol	Component of Change
1	Change in mean export productivity	$\bar{Y}$	$\bar{A}_1 \Delta \bar{Y}$
2	Change in mean export area	$\bar{A}$	$Y_1 \Delta \bar{A}$
3	Interaction between changes in mean productivity and mean area	$\bar{A}\bar{Y}$	$\Delta\bar{A}\Delta\bar{Y}$
4	Change in area-productivity Covariance	CoV(AY)	Δ CoV(AY)

Table 2: Components of Change in the Variance of Production

S.No	Sources of change	Symbol	Component of change
1	Change in main productivity	$\Delta\bar{Y}$	$2\bar{A}_1\Delta\bar{Y}\,CoV(A_1,Y_1) + \{2\bar{Y}_1\Delta\bar{Y} + (\Delta\bar{Y})^2\}V(A_1)$
2	Change in mean area	$\Delta\bar{A}$	$2\bar{Y}_1\Delta\bar{A}\,CoV(A_1,Y_1) + \{2\bar{A}_1\Delta\bar{A} + (\Delta\bar{A})^2\}V(Y_1)$
3	Change in productivity variance	ΔV (Y)	$\bar{A}_1^2\,\Delta V(Y)$
4	Change in area variance	Δ V(A)	$\bar{Y}_1^2\Delta V(A)$
5	Interaction between change in mean productivity and mean area	$\Delta\bar{A}\,\Delta\bar{Y}$	$2\,\Delta\bar{A}\,\Delta\bar{Y}\,CoV(A_1, Y_1)$
6	Change in area productivity covariance	ΔCoV(A,Y)	$\{2\bar{A}_1\bar{Y}_1 - 2\,CoV(A_1, Y_1)\}\,\Delta CoV(A,Y) - \{\Delta\,CoV(A,Y)\}^2$
7	Interaction between change in mean area and productivity variance	$\Delta\bar{A}\Delta V(Y)$	$\{2\,\bar{A}_1\,\Delta\bar{A} + (\Delta\bar{A})^2\}\,\Delta V(Y)$
8	Interaction between change in productivity and area variance	$\Delta\bar{Y}\Delta V(A)$	$\{2\bar{Y}_1\Delta\bar{Y} + (\Delta\bar{Y})^2\}\,\Delta V(A)$
9	Interaction between change in mean area and productivity and changes in area-productivity covariance	$\Delta\bar{A}\Delta\bar{Y}\Delta Cov(A,Y)$	$(2\bar{A}_1\Delta\bar{Y} + 2\bar{Y}_1\Delta\bar{A} + 2\Delta\bar{A}\,\Delta\bar{Y})\,\Delta\,CoV(A, Y)$
10	Change in residual	ΔR	ΔV(AY) - sum of other component

3. Results and Discussion

3.1 Estimation of Compound Annual Growth Rate of aquaculture productions in West Bengal.

The growth rate pattern of aquaculture production of new exportable species for West Bengal during the entire study period is shown in Table.3. Among the major cultures, the largest production increase was achieved by Sea Bass at the annual growth rate of 91.96% per year, followed by Tilapia with growth rate of 43.16% per year. The production of crab and Pangasius cultures increased at the rate of 38.43% and 18.49% per annum, respectively.

Table 3: Annual CGR of aquaculture productions in West Bengal

Particulars	Crab	Sea Bass	Tilapia	Pangasius
Area	1.19%	78.12%	*41.44%	-37.34%
Production	38.43%	91.96%	43.16%	18.49%
Productivity	32.71%	7.41%	3.61%	87.72%

*Significant (p<0.05).

The results of Table 3 reveal that Productivity per mt/ha/year of major culture species, the largest increase has been noticed in case of Pangasius with the annual rate of 87.72% followed by crab with the annual rate of 32.71%. The productivity of Sea Bass and Tilapia has also increased at the annual growth rate of 7.41% and 03.61% respectively. Similarly amongst the major cultures, the largest increase in area was for Sea Bass at the annual growth rate of 78.12%, followed by Tilapia with the significant (p<0.05) improvement in area annual rate of 41.44% during study period. The growth rates for Crab were found at 1.19% per year and also the Non-significant declined area growth rate for Pangasius were found (-) 37.34% per annum due to production variability exists from farm to farm and location to location, which indicates that production risk may be a problem in pangas farming and also dearth of quality seed, inconsistent management practices, prevalence of stress induced diseases (Ahmaruzzaman, At le & Kristin, 2018; Seshagiri *et al*., 2021) [1, 27]. The profits in Pangasius culture have declined from 54% in 2004 to 18% in 2019. Exceptionally, farmers have incurred loss of 9% during COVID Pandemic. In spite of highly fluctuating markets in India (Mohan, Gopal & Ravibabu, 2019) [18].

3.2 Decomposition of Output Growth Analysis of Individual Aquaculture.

The growth analysis (area, production and productivity) of major cultures revealed the general pattern of growth and direction of changes in productivity and area. But this analysis does not evaluate the contribution of area and productivity towards the production growth. So, it is necessary to examine the sources of output growth. To appraise the sources of output growth for major cultures, the change in production is divided in to three effects i.e., area effect, productivity effect and interaction effect. The relative contribution of area, productivity and their interaction to changes in production of individual cultures is presented in Table 4.

Table 4: Growth Decomposition in Culture production in West Bengal

Component Changes	Crab	Sea Bass	Tilapia	Pangasius
Area Effect	-1.91	263.25	57.23	-37.25
Productivity Effect	125.60	-8.55	3.66	289.45
Interaction Effect	-23.96	-154.70	39.45	-152.34
Total Change	100	100	100	100

The decomposition analysis of the growth of major cultures over the entire study period (2012-13 to 2020-21) revealed that growth in production of Pangasius (289.45%) and Crab (125.60%) was mainly due to productivity effect. However, the decomposition analyses show that production of Sea Bass and Tilapia was mainly due to area effect. About 263.25% (for Sea Bass) to 57.23% (for Tilapia) growths in aquaculture were due to area effect. It is evident from the table.4, that during study period productivity effect was seen as the most responsible factor for changing the crab culture production in West Bengal i.e. 125.60% with Area effect and interaction effect were being negative i.e. -1.91% and -23.96% due to the increase in demand for orange mud crabs; farmers now harvest mud crabs of smaller size and generally rear crabs in their fisheries. Some rear in riverside small fish ponds. Some farmers don't have any specific regions for rearing mud crabs and hence sell it to byaparis (Misha, Ajanta & Deblina, 2021) [16]. And also due to the fishable and cultivable areas of crabs in West Bengal, it is apparent that there is scope for augmentation of crab production in this region particularly through cultural practice (Nandi & Dev Roy, 1998; Nandi & Pramanik, 2015) [19, 20]. This is because there is no organized crab fishery in this region and the fishermen communities are also not aware of technical knowhow of crab culture. Thus, the production of mud crabs may be enhanced by way of scientific and organized fishing as well as by semi-intensive farming. However, much caution needs to be taken to avoid over-exploitation from natural sources. Furthermore, as the crab meat is rich in protein which is comparable to marine and freshwater fishes and molluscs, augmentation of crab production may solve the demand for protein requirement in India as well as West Bengal (Roy and Nandi, 2019) [26]. Although hatchery seeds are available but it has limitations owing to the poor survival of larvae. To resolve the problems of the farmers it is suggested to improve modern hatchery technology (Taposh, 2022) [32]. Similarly results were seen during the study period with area effect 263.25% as the most responsible factor for changing the Sea Bass culture production due to greater attention and has been increasingly farmed commercially in modified-extensive systems in large freshwater impoundments (termed 'mitthe gh eri' in local dialect), mainly at the Canning-II, Kolati and Joysagar-I Blocks of South 24 Parganas District. It is reported to grow well (Thirunavukkarasu *et al*., 2008; Ghosh, 2019) [33, 10] and faster in freshwater (Ghosh, 1971) [9]. But productivity effect and interaction effect were found to be negatively decline i.e.–8.55 and–154.70% due to the changing economic conditions may also have played a role in this decline. And also results were seen during the study period with area effect 57.23% as the most responsible factor for changing the Tilapia culture production but productivity effect and interaction effect were found to be positive i.e. 3.66 and 39.45% respectively. The main reason is Tilapia are also attractive as a co-cultured fish because of their potential to improve water quality, temperature, DO, pH and waste that can be accustomed for maximum production and also especially in pen aeid shrimp ponds, by consuming plankton and detritus and by altering pathogenic bacterial populations while increasing marketable production (Menaga *et al*., 2019; El-Saidy & Hussein, 2015) [14, 5]. Thus, androgen hormone treated (sex-inversion is the oral administration) in mono sex tilapia culture in tank as a substitute of earthen ponds can be regarded as one of the advance method for eco-socio-economic condition increased fish production in West Bengal. Tilapia has been extensively introduced in the shallow and seasonal ponds of eastern region of India (Ghorai, 2021) [8]. While in case of productivity effect was seen as the most responsible factor for changing the Pangasius production in West Bengal i.e. 289.45% with area effect and interaction effect were found to be negative trend i.e.–37.25 and–152.34% due to the general effects of climate change on freshwater systems are increased water temperatures and decreased dissolved oxygen levels. Increasing temperatures can affect individual fish by altering physiological functions, such as thermal tolerance, growth, metabolism, food consumption, reproductive success and their ability to maintain internal homeostasis in a variable external environment (Fry, 1971; Ficke, Myrick & Hansen, 2007) [7, 6].

3.3 Decomposition analysis of the components of change in the average production and variance production of aquaculture

The analysis was carried out to identify the sources influencing growth on the average and variances of aquaculture production of new exportable species. Major new exportable species such as Crab, Sea Bass, Tilapia and Pangasius were chosen to perform the decomposition analysis to quantify the sources of growth in production average and variance of productivity. The results were furnished in table.5 & 6 and it represents the different components influencing variability in the production of new exportable species in terms of change in the mean productivity and change in mean area, the effect of interaction between changes in mean area and mean productivity and the change in covariance between area and productivity was analyses by using Hazel Decomposition statistical procedure. The decomposition analysis was carried out and percentage contribution of each component towards the change in average aquaculture Production was estimated for west Bengal.

Table 5: Percent contribution of each component in change in Average Production

Source of Changes	Symbol	Crab	Sea Bass	Tilapia	Pangasius
Change in mean productivity	$\bar{Y}$	728.75	101.60	-103.44	750.93
Change in mean area	$\bar{A}$	108.38	210.59	271.87	-405.26
Interaction between change in mean area and mean productivity	$\bar{A}\bar{Y}$	200.33	107.44	-84.65	-522.13
Change in area – productivity Covariance	CoV(AY)	-937.44	-319.62	16.63	275.97
Total		100	100	100	100

From table.5, the contribution of change in mean productivity was the highest across all other components of change. As expected the percent contribution of the change in mean productivity in mean production was highest in Pangasius (750.93%) followed by Crab (728.75%) and Sea Bass (101.60%). Whereas the tilapia is recorded a negative (-103.44%) growth rate during the study period. The contribution to mean production by change in mean area is highest in Tilapia (271.87%) followed by Sea Bass (210.59%) and Crab (108.38%) respectively. In Pangasius this contribution of change in mean area is (-) 405.26 percent decrease in the mean production. With regard to interaction effect, The contribution of interaction between changes in mean productivity and mean area was negative in case of Tilapia(-84.65%) and Pangasius (-522.13%) but positive in case of Crab(200.33%) and Sea Bass(107.44%). The contribution of change in area–productivity covariance in growth of production was very small (13.63%) and highest value accounted in Pangasius (275.97%) but negative contribution in crab (-937.44%) and sea bass (-319.62%).

Table 6: Percent contribution of each component in change in variance of production

Components	Symbol	Crab	Sea Bass	Tilapia	Pangasius
Change in mean productivity	$\Delta\bar{Y}$	321.80	-62.90	86.74	83.0597
Change in mean area	$\Delta\bar{A}$	9.74	-196.33	-129.21	17.9205
Change in productivity variance	$\Delta V(Y)$	984.10	-115.82	44.91	25.3145
Change in area variance	$\Delta V(A)$	78.09	-35.60	160.91	28.7435
Interaction between change in mean productivity and mean area	$\Delta\bar{A}\ \Delta\bar{Y}$	-10.35	6.70	-1.91	-31.205
Change in area productivity covariance	$\Delta CoV(A,Y)$	-770.42	368.73	-11.38	-38.146
Interaction between change in mean area and productivity variance	$\Delta\bar{A}\Delta V(Y)$	819.90	-499.32	129.95	-37.619
Interaction between change in productivity and area variance	$\Delta\bar{Y}\Delta V(A)$	429.30	-29.39	-62.84	91.3319
Interaction between change in mean area and productivity and changes in area-productivity covariance	$\Delta\bar{A}\Delta\bar{Y}\Delta Cov(A,Y)$	-961.13	302.78	9.08	-14.323
Change in residual	ΔR	-801.39	361.15	-126.74	-24.803
Total		100	100	100	100

The results presented in Table 6 depicts that among the ten constituents of change in variance of culture production of change in productivity variance in Crab, followed by Interaction between change in mean area and productivity variance contributed more towards instability. It is evident that change in productivity variance accounted for as high as 984.10% of the total change in the variance of culture production. The Interaction between change in mean area and productivity variance contributed around 819.90%. The Change in productivity variance and Interaction between change in mean area and productivity variance were two important components explaining large proportions of variability in crab production. Change in area productivity covariance, Interaction between change in mean productivity and mean area, Interaction between change in mean area and productivity and changes in area-productivity covariance are negative. That is decrease in production variance with decline in productivity could happen in crab as in the last eight years. There is no increase in yield. The pattern was different for different crops (cultures). In case of sea bass, change in area-productivity co-variance accounted for the largest share followed by Interaction between change in mean area and productivity and changes in area-productivity covariance and Change in residual. In case of Tilapia, change in area variance accounted for most of the changes in the variance of production followed by an Interaction between change in mean area and productivity variance. In case of Pangasius, change in area variance accounted for most of the Interaction between change in productivity and area variance followed by a change in main productivity.

4. Conclusions

The largest annual growth rate was found sea bass in production followed by Pangasius in Productivity and Sea Bass in area respectively. The significant development in Tilapia culture area by 41.44% in study period. For the entire study period of 2013-14 to 2020-21, results for decomposition output growth show that in case of crab and pangasius, the major growth factor was the productivity effect, but for sea bass and tilapia the main growth source was the area effect. The results of the decomposition of change in average culture production in West Bengal shows, among the four constituents of change in average production of four Cultures, change in mean productivity contributed maximum in pangasius to change in mean of production in study period, followed by Change in mean productivity in Crab culture. The change in mean productivity was primary source of growth in pangasius and crab. Similarly, the change in mean area was major source of growth in Sea Bass and Tilapia in west Bengal during study period. The Change in productivity variance and Interaction between change in mean area and productivity variance were two important components explaining large proportions of variability in crab production. In case of sea bass, change in area-productivity co-variance accounted for the largest share followed by Interaction between change in mean area and productivity and changes in area-productivity covariance. Among remaining culture crops, Change in area productivity covariance in case of sea bass and Change in area variance in case of tilapia and also Interaction between change in productivity and area variance in case of Pangasius accounted for large increases in the variability of their production.

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6. Conflicts of Interest

The authors confirm that there are no known conflicts of interest associated with this publication.

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