**Tabel 1.**  Parameter kesesuaian kualitas air untuk produksi udang Vannamei

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Parameter** | **Unit** | **Kisaran Kesesuaian** | **Kisaran Optimal** | **Referensi** |
| 1 | Suhu | °C | 5 – 35 | 26 – 33 | Boyd and Tucker (2014); Karthik et al. (2005); (Mustafa, 2012; Ross et al., 2013) |
| 2 | Salinitas | ‰ | 10 – 35 | 15 – 25 |
| 3 | Kecerahan | cm | 20 – 60 | 30 - 45 | Boyd and Tucker (2014); Mustafa (2012); Mohanty et al. (2018) |
| 4 | Oksigen terlarut | mg L-1 | > 3 | > 5 | Mohanty et al. (2018) |
| 5 | pH (Derajat keasaman) |  | 6 – 9 | 7.5 – 8.5 | Boyd and Tucker (2014); Mustafa (2012) Tarunamulia (2014), Mohanty et al. (2018) |
| 6 | Total Ammonia | mg L-1 | < 1.0 | < 1.0 | Boyd and Tucker (2014); Mohanty et al. (2018) |
| 7 | Amonia bebas | mg L-1 | < 0.3 | < 0.1 | Mustafa (2012); Tarunamulia (2014) |
| 8 | Nitrit | mg L-1 | < 0.25 | < 0.05 | Karthik et al. (2005),Tarunamulia (2014), Mohanty et al. (2018) |
| 9 | Nitrat | mg L-1 | * 1. - 0.8 | < 0.3 | Karthik et al. (2005),Tarunamulia (2014), Mohanty et al. (2018) |
| 10 | Hidrogen Sulfida | mg L-1 | < 0.25 | <0.1 | Carbajal-Hernández et al. (2013), (Mohanty et al., 2018) |
| Logam berat (Standar Baku Mutu Air Peraturan Pemerintah No 22/2021 Lampiran VI) | | | | | |
| 11 | Merkuri | mg L-1 | < 0.0025 | < 0.001 | PP No 22/2021 Lampiran VI |
| 12 | Tembaga | mg L-1 | < 0.1 | < 0.002 | PP No 22/2021 Lampiran VI |
| 13 | Besi | mg L-1 | < 0.01 | < 0.01 | PP No 22/2021 Lampiran VI, Tarunamulia (2014) |
| 14 | Seng | mg L-1 | < 0.25 | < 0.05 | PP No 22/2021 Lampiran VI |
| 15 | Kadmium | mg L-1 | < 0.15 | < 0.01 | PP No 22/2021 Lampiran VI |
| Pestisida dan lainnya | | | | | |
| 16 | Malathion | µg L-1 | < 0.0004 | < 0.01 | (Ross et al., 2013) |
| 17 | Parathion | µg L-1 | < 0.001 | < 0.01 | (Ross et al., 2013) |
| 18 | Arzodine | µg L-1 | < 0.01 | < 0.01 | (Ross et al., 2013) |
| 19 | Paraquat | µg L-1 | < 0.01 | < 0.01 | (Ross et al., 2013) |
| 20 | Endosulfan | µg L-1 | < 0.01 | < 0.01 | (Ross et al., 2013) |

**Tabel 2.**  Parameter kesesuaian kualitas tanah untuk produksi udang Vannamei

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Parameter** | **Unit** | **Kisaran Kesesuaian** | **Kisaran Optimal** | **Referensi** |
| 1 | pHF-pHFOX |  | 0.1 – 4.0 | < 0.5 | (Ross et al., 2013); Mustafa et al. (2012) |
| 2 | pH |  | 6.5 – 8.5 | 6.5 – 9.5 | Karthik et al. (2005); (Ross et al., 2013) |
| 3 | Liat | (%) | 3 - 30 | 3 - 20 | Karthik et al. (2005);Tarunamulia (2014) |
| 4 | Karbon-organik | (%) | 0.5 – 8.0 | 1.5 – 2.5 | Karthik et al. (2005), Mustafa et al. (2012) |
| 5 | Kedalaman pirit | (m) | > 2.5 | > 1.0 | Mustafa et al. (2012), Tarunamulia (2014); Ross et al. (2013) |
| 6 | Total nitrogen | (%) | > 0.16 | >0.21 | Tarunamulia (2014); (Ross et al., 2013) |
| 7 | Posfat | mg L-1 | > 46 | > 36 | Tarunamulia (2014) |

**Tabel 3.** Contoh indikator yang digunakan untuk penentuan daya dukung sebuah sistem produksi

|  |  |  |  |
| --- | --- | --- | --- |
| Kategori | Indikator | Pendekatan yang digunakan | Referensi |
| Daya dukung fisik | 1. Ketersediaan air 2. Akses ke air 3. Hidrografi 4. Oseanografi 5. Hidrodinamika | 1. Analisis kesesuaian lahan 2. Zonasi 3. Pengelolaan kawasan pantai 4. Perubahan iklim 5. Penilaian Resiko | Ross et al. (2013), Karthik et al. (2005)  Mustafa et al. (2012) |
| Daya dukung produksi | 1. Akses adan kualitas jalan 2. Nilai/harga lahan 3. Ketersediaan benih 4. Ketersediaan pakan dan pupuk 5. Ketersediaan pasar 6. Listrik 7. Ketersediaan permesinan dan bahan kimia | 1. Analisis Kesesuaian lahan 2. Analisis rantai pasok 3. Queuing Analysis 4. Analisis spasial/kedekatan (distance analysis) | Karthik et al. (2005)  (Wang et al., 2021)  Ross et al. (2013) |
| Daya dukung lingkungan | 1. Kualitas air 2. Kualitas tanah 3. Jalur hijau mangrove 4. Kemampuan asimilasi lingkungan budidaya 5. Penampakan visual/Visual amenities 6. Batasan kawasan konservasi dan ekosistem unik lainnya | 1. Analisis Kesesuaian lahan 2. Monitoring kualitas air 3. Zonasi budidaya 4. Pengelolaan kawasan pantai 5. Kecepatan dekomposisi bahan organik 6. Keanekaragaman organisme/ makrobentos perairan sekitar | Karthik et al. (2005)  Mustafa et al. (2012)  Ross et al. (2013) |
| Daya dukung sosial | 1. Ketersediaan tenaga kerja dan literasi 2. Ketersediaan tenaga penyuluh/sumber informasi 3. Ketersediaan fasilitas lain (pos, bank, faskes, kelompok pembudidaya, | 1. Analisis kesesuaian sosial dan ekonomi 2. Analisis spasial/kedekatan (distance analysis) 3. Analisis rantai pasok 4. Queuing Analysis | Karthik et al. (2005)  Wang et al. (2021)  Ross et al. (2013) |

**Tabel 4.** Database kebutuhan nutrisi spesifik udang Vannamei yang dibudidayakan dalam sistem intensif untuk beberapa ukuran udang dimulai dari starter hingga ukuran konsumsi atau induk (> 40 g). Data dirangkum dari The International Aquaculture Feed Formulation Database (IAFFD)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Unit** | **Kondisi** | **Ukuran Udang** | | | |
| **< 3 g** | **3 - 15 g** | **15 - 40 g** | **> 40 g** |
| Kelembapan | % | Minimum | 10 | 10 | 10 | 10 |
| Crude Protein | % | Minimum | 42 | 37 | 36 | 35 |
| Crude Lipids | % | Minimum | 5 | 6 | 6 | 7 |
| Starch | % | Minimum | 12 | 13 | 13 | 13 |
| Arginin | % | Minimum | 2.50 | 2.41 | 2.35 | 2.30 |
| Histidin | % | Minimum | 0.71 | 0.69 | 0.67 | 0.66 |
| Isoleusin | % | Minimum | 1.47 | 1.42 | 1.39 | 1.37 |
| Leusin | % | Minimum | 2.49 | 2.36 | 2.29 | 2.22 |
| Lysin | % | Minimum | 2.65 | 2.54 | 2.46 | 2.40 |
| Methionin | % | Minimum | 0.94 | 0.91 | 0.88 | 0.86 |
| Phenylalanin | % | Minimum | 1.69 | 1.64 | 1.61 | 1.58 |
| Threonin | % | Minimum | 1.29 | 1.22 | 1.19 | 1.15 |
| Tryptophan | % | Minimum | 0.33 | 0.32 | 0.31 | 0.31 |
| Valin | % | Minimum | 1.68 | 1.60 | 1.55 | 1.51 |
| Cystin | % | Minimum | 0.31 | 0.30 | 0.30 | 0.29 |
| TSAA (Met+Cys) | % | Minimum | 1.25 | 1.21 | 1.18 | 1.15 |
| Tyrosin | % | Minimum | 1.26 | 1.23 | 1.21 | 1.19 |
| Phe+Tyr | % | Minimum | 2.95 | 2.87 | 2.82 | 2.77 |
| Sum EAAs | % | Minimum | 17.31 | 16.63 | 16.22 | 15.84 |
| Taurine | % | Minimum | 0.30 | 0.20 | 0.20 | 0.20 |
| EPA 20:5 n-3 | % | Minimum | 0.33 | 0.29 | 0.25 | 0.22 |
| DHA 22:6 n-3 | % | Minimum | 0.50 | 0.43 | 0.38 | 0.34 |
| EPA+DHA | % | Minimum | 0.84 | 0.72 | 0.64 | 0.56 |
| Sum n-3 | % | Minimum | 0.78 | 0.78 | 0.78 | 0.78 |
| Arachidonic 20:4 n-6 | % | Minimum | 0.010 | 0.005 | 0.005 | 0.005 |
| Sum n-6 | % | Minimum | 0.5 | 0.5 | 0.5 | 0.5 |
| Phospholipids | % | Minimum | 1.3 | 1.1 | 1.0 | 1.0 |
| Kolesterol | mg | Minimum | 777 | 518 | 518 | 518 |
| Phosphorus | % | Minimum | 0.93 | 0.64 | 0.53 | 0.42 |
| Natrium | % | Minimum | 0.16 | 0.16 | 0.16 | 0.16 |
| Klorin | % | Minimum | 0.16 | 0.16 | 0.16 | 0.16 |
| Kalium | % | Minimum | 0.3 | 0.3 | 0.3 | 0.3 |
| Magnesium | % | Minimum | 0.07 | 0.07 | 0.07 | 0.07 |
| Copper | mg | Minimum | 7.8 | 7.8 | 7.8 | 7.8 |
| Besi | mg | Minimum | 98 | 98 | 98 | 98 |
| Mangan | mg | Minimum | 10.4 | 10.4 | 10.4 | 10.4 |
| Selenium | mg | Minimum | 0.16 | 0.16 | 0.16 | 0.16 |
| Seng | mg | Minimum | 31 | 31 | 31 | 31 |
| Iodin | mg | Minimum | 1.04 | 1.04 | 1.04 | 1.04 |
| Vitamin C | mg | Minimum | 207 | 155 | 155 | 207 |
| Biotin-B7 | mg | Minimum | 0.52 | 0.52 | 0.52 | 0.52 |
| Folic acid-B9 | mg | Minimum | 5.2 | 5.2 | 5.2 | 5.2 |
| Niacin-B3 | mg | Minimum | 27 | 27 | 27 | 27 |
| Pantothenic Acid-B5 | mg | Minimum | 16 | 16 | 16 | 16 |
| Pyridoxine-B6 | mg | Minimum | 10 | 10 | 10 | 10 |
| Riboflavin-B2 | mg | Minimum | 15.5 | 15.5 | 15.5 | 15.5 |
| Thiamin-B1 | mg | Minimum | 4.1 | 4.1 | 4.1 | 4.1 |
| Vitamin B12 | mg | Minimum | 0.01 | 0.01 | 0.01 | 0.01 |
| Vitamin A | mg | Minimum | 2.07 | 1.45 | 0.93 | 0.93 |
| Vitamin D | ug | Minimum | 41 | 31 | 10 | 10 |
| Vitamin E | mg | Minimum | 233 | 155 | 155 | 155 |
| Vitamin K | mg | Minimum | 3.1 | 3.1 | 3.1 | 3.1 |
| Choline | mg | Minimum | 1036 | 1036 | 1036 | 1036 |
| Inositol | mg | Minimum | 155 | 155 | 155 | 155 |
| Aflatoxin B | ppb | Maximum | 19 | 19 | 19 | 19 |
| Deoxynivalenol (DON) | ppb | Maximum | 305 | 610 | 966 | 966 |
| Zeralenone (ZON) | ppb | Maximum | 305 | 610 | 610 | 610 |
| Fumonicin (FUM) | ppb | Maximum | 2032 | 2033 | 2033 | 2033 |
| Anti-trypsic factors | mg | Maximum | 4066 | 8131 | 8131 | 8131 |
| Gossypol | mg | Maximum | 152 | 254 | 305 | 305 |
| Phytic Acid | g | Maximum | 4.8 | 7.2 | 9.7 | 9.7 |
| Glucosinolates | mmol | Maximum | 1.0 | 1.9 | 2.9 | 3.9 |
| Sinapine | mg | Maximum | 1016 | 1525 | 1525 | 2033 |
| Lectins | mg | Maximum | 508 | 1016 | 1016 | 1016 |
| Cyanogens | mg | Maximum | 51 | 97 | 97 | 97 |
| Soyasaponins | mg | Maximum | 457 | 915 | 1372 | 1372 |
| Isoflavones | mg | Maximum | 2033 | 2541 | 2541 | 2541 |

**Tabel 5.** Daftar beberapa penyakit penting pada sistem produksi udang putih *Litopenaeus vannamei*

|  |  |  |
| --- | --- | --- |
| **Jenis penyakit** | **Patogen Penyebab penyakit** | **Referensi** |
| Acute hepatopancreatic necrosis disease (AHPND) | *Vibrio parahaemolyticus, V. campbellii, V. owensii and V. harveyi* | Jun et al. (2018); Liu et al. (2018); Muthukrishnan et al. (2019) |
| Covert Mortality nodavirus (CMNV) | RNA virus | Zhang et al. (2017) |
| Shrimp hemocyte iridescent virus (SHIV) | Iridoviridae, DNA virus | Qiu et al. (2017) |
| White spot disease (WSD) /WSSV | Nimaviridae, DNA virus | (Ruiz-Velazco et al., 2010; Wang et al., 1999) |
| Taura syndrome virus (TSV) | Picornaviridae, RNA virus | Argue et al. (2002) |
| Infectious myonecrosis virus (IMNV) | Totiviridae, RNA virus | (Nur’aini, 2009; Tang et al., 2005) |
| Infectious hypodermal and haematopoietic necrosis virus (IHHNV) | Parvoviridae | (Escobedo-Bonilla and Rangel, 2014; Kim et al., 2011) |
| Vibriosis (eg. Vibrio harveyi, V. parahaemolyticus) | Bacteria | (Longyant et al., 2008; Mohney et al., 1994) |
| Hepatobacter penaei / necrotizing hepatopancreatitis (NHP) | alpha - proteobacterium | Nunan et al. (2013) |
| Black gill disease | Fungal infection in the gill | Wang et al. (2020); Karthikeyan et al. (2015) |
| Zoothamnium | Protozoa | Hafidloh and Sari (2019) |

**Tabel 6.** Analisa kelayakan ekonomi untuk 1 unit cluster sistem produksi udang *Litopenaeus vannamei* skala intensif. 1 unit kluster terdiri atas 10 kolam produksi, 4 kolam pengelolaan air masuk, 1 unit kolam karantina dan 1 unit kolam pengelolaan air limbah.

Asumsi yang digunakan:

1. 1 siklus produksi = 120 hari
2. 1 tahun produksi = 3 siklus

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **JUMLAH KOLAM DALAM SATU KLUSTER** | | | | | | | | | | | |
| No | Item | | Panjang (m) | Lebar (m) | | Kedalaman (m) | | Jumlah (unit) | Luas Lantai (m2) | | Tot Luas Lantai (m2) |
| 1 | Kolam Produksi | | 45,00 | 45,00 | | 1,50 | | 10 | 2.025 | | 20.250 |
| 2 | Kolam pengelolaan air masuk | | 55,00 | 45,75 | | 1,50 | | 4 | 2.516 | | 10.065 |
| 3 | Kolam karantina | | 94,50 | 30,00 | | 1,50 | | 1 | 2.835 | | 2.835 |
| 4 | Kolam pengelolaan air limbah | | 54,50 | 40,00 | | 2,00 | | 1 | 2.180 | | 2.180 |
|  | **Total luas lahan produksi** | | | | | | | | | | 35.330 |
|  |  | |  |  | |  | |  |  | |  |
| Karakteristik jumlah dan biaya benur yang digunakan | | | | | | Per Modul | | Per Kolam | Satuan | |  |
| 1 | Padat Tebar | | 300 | Ekor/m2 | |  | |  |  | |  |
| 2 | Jumlah Tebar | | 6.075.000 | Ekor | | 6.075.000 | | 607.500 | Ekor | |  |
| 3 | Harga Benur | | 43 | Rp/Ekor | | 261.225.000 | | 26.122.500 | Rp | |  |
|  |  | |  |  | |  | |  |  | |  |
| Jumlah pakan per siklus = 120 hari | | | | | | Per Modul | | Per Kolam | Satuan | |  |
| **1** | FCR | | 1,3 |  | |  | |  |  | |  |
| **2** | Jumlah Panen | |  |  | | 114.223 | | 11.422 |  | |  |
| **3** | Jumlah Pakan | |  |  | | 148.490 | | 14.849 | Kg | |  |
| **4** | Harga Pakan | | 16.850 | Rp/Kg | | 2.502.063.759 | | 250.206.376 | Rp | |  |
|  |  | |  |  | |  | |  |  | |  |
| **Biaya Produksi per siklus dan per tahun** | | | | | | | | | |
| **No** | | **Item** | | | **Biaya Produksi per Siklus** | | **Biaya Produksi per Tahun** | | |
| **Total** | | **Total** | | |
| 1 | | Biaya Persiapan Kolam | | | 20.250.000 | | 60.750.000 | | |
| 2 | | Biaya Benur | | | 261.225.000 | | 783.675.000 | | |
| 3 | | Biaya Pakan | | | 2.502.063.759 | | 7.506.191.278 | | |
| 4 | | Biaya Kapur | | | 5.804.400 | | 17.413.200 | | |
| 5 | | Biaya Pupuk | | | 1.539.090 | | 4.617.270 | | |
| 6 | | Obat-obatan, Desinfektan, Probiotik, dll | | | 22.669.138 | | 68.007.414 | | |
| 7 | | Biaya Listrik PLN | | | 288.000.000 | | 864.000.000 | | |
| 8 | | Biaya Solar (BBM Genset) | | | 21.000.000 | | 63.000.000 | | |
| 9 | | Biaya Tak Terduga | | | 100.000.000 | | 300.000.000 | | |
|  | |  | | | 3.222.551.387 | | 9.667.654.162 | | |
| **Biaya Karyawan per siklus dan per tahun** | | | | | | | | | |
| No | | Item | | | Biaya Karyawan per Siklus | | Biaya Karyawan per Tahun | | |
| Total | | Total | | |
| 1 | | Gaji Farm Manager | | | 13.000.000 | | 39.000.000 | | |
| 2 | | Gaji Farm Supervisor | | | 20.000.000 | | 60.000.000 | | |
| 3 | | Gaji Pekerja Tambak | | | 312.000.000 | | 936.000.000 | | |
| 4 | | Gaji - Security | | | 102.000.000 | | 306.000.000 | | |
| 5 | | Uang Makan | | | 48.000.000 | | 144.000.000 | | |
|  | |  | | | 495.000.000 | | 1.485.000.000 | | |
|  | |  | | |  | |  | | |
| TOTAL Biaya produksi dan karyawan | | | | | 3.717.551.387 | | 11.152.654.162 | | |
|  | |  | | |  | |  | | |
| Nilai Jual Udang dengan 3 (tiga) skenario kelulushidupan | | | | | | | | | | |  |
| Harga Jual Udang Rp/Kg | | | 65.000 |  | |  | |  |  | |  |
| Kelulushidupan | | | 90% | 75% | | 60% | |  |  | |  |
| 1 | Panen 1 (DOC 70) | | 374.092.105 | 311.743.421 | | 249.394.737 | |  |  | |  |
| 2 | Panen 2 (DOC 90) | | 1.719.616.935 | 1.433.014.113 | | 1.146.411.290 | |  |  | |  |
| 3 | Panen total (DOC 120) | | 5.330.812.500 | 4.442.343.750 | | 3.553.875.000 | |  |  | |  |
|  |  | | 7.424.521.541 | 6.187.101.284 | | 4.949.681.027 | |  |  | |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| No | Deskripsi | Kelulushidupan 90% | | Kelulushidupan 75% | | Kelulushidupan 60% | |
| Per Siklus | Per Tahun | Per Siklus | Per Tahun | Per Siklus | Per Tahun |
| 1 | Pendapatan | 7.424.521.541 | 22.273.564.622 | 6.187.101.284 | 18.561.303.852 | 4.949.681.027 | 14.849.043.081 |
| 2 | Biaya operasional | 3.717.551.387 | 11.152.654.162 | 3.717.551.387 | 11.152.654.162 | 3.717.551.387 | 11.152.654.162 |
|  | Keuntungan kasar | 3.706.970.154 | 11.120.910.461 | 2.469.549.897 | 7.408.649.690 | 1.232.129.640 | 3.696.388.920 |
| 4 | Bonus Produksi (10%) | 370.697.015 | 1.112.091.046 | 246.954.990 | 740.864.969 | 123.212.964 | 369.638.892 |
| 5 | Depresisasi (20 %) | 741.394.031 | 2.224.182.092 | 493.909.979 | 1.481.729.938 | 246.425.928 | 739.277.784 |
|  | Keuntungan bersih | 2.594.879.107 | 7.784.637.322 | 1.728.684.928 | 5.186.054.783 | 862.490.748 | 2.587.472.244 |
| 6 | Modal investasi | 8.955.570.106 |  | 8.955.570.106 |  | 8.955.570.106 |  |
|  | PAY BACK PERIODE (Siklus) | **4,9** |  | **7,3** |  | **14,7** |  |

**Gambar 1.** Grafik logaritmik pertumbuhan udang di empat kepadatan berbeda dengan 8 replikat selama proses produksi. Titik yang disajikan merupakan data rata-rata ± standar deviasi untuk delapan replikat. Disadur dari Novriadi et al. (2020)

**Gambar 2.** Proses tinjauan kesiapan produksi udang putih *Litopenaeus vannamei*

**POLA PRODUKSI UDANG SISTEM INTENSIF**

**LAHAN PRODUKSI**

**Daya dukung lingkungan**

**Daya dukung sosial ekonomi**

**Daya dukung produksi**

**Daya dukung fisik**

**Penentuan Sistem Produksi**

Kolam Produksi

**Manajemen Produksi**

**TEKNOLOGI DAN STANDARISASI**

Padat tebar

Pengelolaan pakan

Pengelolaan air

Pengelolaan kesehatan

Biosekuriti

**PASAR**