Journal of Fisheries & Livestock Production

Muhammad et al., J Fisheries Livest Prod 2016, 4:4
DOI: 10.4172/2332-2608.1000197

Research Article

Open Access

Biological, Technical, and Financial Feasibilities Study of Zero Water Discharge (ZWD) System Application in Low Salinity White Shrimp (*Litopenaeus vannamei* Boone) Urban Aquaculture, Study Case: Gresik District, East Java, Indonesia

Muhammad H[1], Situmorang ML[2], Djohan YA[2], Aditiawati P[2] and Suantika G[2]*

[1]Department of Biomanagement, School of Life Sciences and Technology, Indonesia
[2]Institute Teknologi Bandung (ITB), Jalan Ganesha No. 10 Bandung 40132, Microbial Biotechnology Research Group, School of Life Sciences and Technology, Indonesia

Abstract

The study was aimed to analyze low salinity white shrimp (*Litopenaeus vannamei* Boone) production feasibility using zero water discharge (ZWD) system. The research was conducted through five constitutive steps: (1) ZWD system installation and white shrimp post-larvae acclimatization to low salinity water (5 ppt), (2) White shrimp cultivation using low salinity ZWD system at three different stocking densities (200 in d/m^3, 300 in d/m^3, and 400 in d/m^3) in 20 m^3 ponds, (3) Biological feasibility and water quality analysis, (4) Technical feasibility analysis, and (5) Production scheme development and financial feasibility analysis to produce 1,000 kg shrimp/cycle. The best biological performance was achieved at 400 in d/m^3 stocking density with survival rate, feed conversion ratio, specific growth rate and total biomass values of 70.59 ± 6.15%, 1.14 ± 0.14, 4.40 ± 0.25%BW/day, and 44.13 ± 4.44 kg, respectively. The best pH level (7.61-8.27), DO (4.9-8.5 mg/L), temperature (29.3-30.1°C), NH_4^+ level (0.0-0.5 mg/L), NO_2^- level (0.0-5.0 mg/L), and NO_3^- level (5.0-30.0 mg/L) were observed at 200 in d/m^3 stocking density. Considering these parameters: water sources, biophysical condition, and land topography, market access and material supplier, the ZWD system was technically feasible for the north-coastal areas of East Java. Production scheme development needed six operational units consisted of (1) purchasing and inventory, (2) water and wastewater treatment, (3) shrimp production, (4) harvesting, (5) transaction and archive, and (6) marketing and distribution. To produce 1,000 kg shrimp/cycle in 70 days culture period, 2-3 human resources and 1,000-1,250 m^2 production area were required. Financial analysis showed that ZWD system was feasible at 300 in d/m^3 and 400 in d/m^3 stocking density, showing positive NPV Rp 47,593,537 and Rp 69,439,955, and IRR value higher than discount factor of 13.40% and 15.49%, respectively. It can be concluded that the implementation of ZWD system for urban shrimp aquaculture production at low salinity (5 ppt) and high stocking density (300 in d/m^3 and 400 in d/m^3) was biologically, technically, and financially feasible to be applied in Gresik on the north-coastal area of East Java Province, Indonesia.

Keywords: *Litopenaeus vannamei* Boone; low salinity; Zero Water Discharge; Technical feasibility; financial feasibility; urban aquaculture

Introduction

Aquaculture has become the fastest-growing food sector since last three decades, with an average growth rate around 8.6% each year [1]. Among fishery commodities, shrimp had contributed for the highest transaction value approximately 15% of total transaction value in fishery commodities. In Indonesia, shrimp was considered as one fishery commodity that listed in the top ten main export commodities [2].

Indonesia shrimp production in 2014 was 623.000 metric tons, which was dominated by white shrimp species (*Litopenaeus vannamei*), with the contribution of up to 69.5% of shrimp total production [3]. The production actually does not ensure the sustainability of the particular industry, because most shrimp farms use conventional culture technology (typically a batch/static or a flow-through system). The existing shrimp rearing strategy that widely applied is still economically profitable for the farmers due to its simplicity and acceptable production cost. However, since the cultivation relies on an outdoor earthen pond with less attention paid to water quality and disease/predation control, it is not surprising that the shrimp production is often unpredictable under this culture condition [4].

The accumulation of harmful substances from uneaten feed and excretion (e.g. ammonium) can exceed the tolerance limits and affect the shrimp productivity in conventional culture system [5]. Besides, the system is considered as not environmentally friendly, because toxic effluent water can pollute the surrounding aquatic environment [4]. In term of space requirement, the system needs large production area and should be closed to coastal area to ensure sea water access. These circumstances will contribute to the inflexibility of shrimp culture and shrimp industry sustainability in the near future. One cultivation strategy, Zero Water Discharge (ZWD) system, was developed to resolve these problems [6,7]. ZWD is an intensive culture technology, which is environmentally friendly as it maintains water quality, therefore prevents pathogen spreading as well as wastewater discharge, that is rich in nutrients, to the environment [8]. The ZWD principle is to limit/reduce water usage, by implementing microbial consortium that recycles nitrogen compound in the culture water, and to clean harmful nitrogen substances before the water is partially or totally reused [6,7]. Based on Suantika et al. [7], by cultivating white shrimp using ZWD system at a laboratory scale, excellent shrimp culture performance reflected by acceptable water quality, 90% survival rate, and low feed conversion ratio (FCR) were obtained. For further development of the system to an industrial scale, research on biological, technical, and

***Corresponding author:** Suantika G, Institute Teknologi Bandung (ITB), Jalan Ganesha No. 10 Bandung 40132 Indonesia, Microbial Biotechnology Research Group, School of Life Sciences and Technology, Indonesia, Tel: +62-22-2500935; E-mail: gsuantika@sith.itb.ac.id1

Received June 30, 2016; **Accepted** July 15, 2016; **Published** July 30, 2016

Citation: Muhammad H, Situmorang ML, Djohan YA, Aditiawati P, Suantika G (2016) Biological, Technical, and Financial Feasibilities Study of Zero Water Discharge (ZWD) System Application in Low Salinity White Shrimp (*Litopenaeus vannamei* Boone) Urban Aquaculture, Study Case: Gresik District, East Java, Indonesia. J Fisheries Livest Prod 4: 197. doi: 10.4172/2332-2608.1000197

financial feasibility needs to be conducted before implementing this low salinity ZWD system in a real aquaculture operation. Therefore, the aim of this current study was to analyze the biological, technical, and financial feasibility of the low salinity white shrimp production using zero water discharge (ZWD) system in an urban, north-coastal area of Gresik, East Java Province, Indonesia.

Materials and Methods

Location and research period

The research was conducted in a small-scale shrimp nursery, UD. Popular, located in Cerme Lor, Gresik, East Java Province, Indonesia. The study carried out for three months (August-October 2015).

Research material

White shrimps larvae were obtained from a commercial hatchery in Situbondo, East Java Province, Indonesia. A pure culture of microorganism consortium consisting microalgae *Chaetoceros calcitrans,* nitrifying bacteria, and probiotic *Bacillus megaterium* was obtained and cultured at the Laboratory of Microbiology, School of Life Sciences and Technology, Institut Teknologi Bandung, Indonesia. Microalage *C. calcitrans* was cultured in Guilard F/2 medium and propagated in NPK-silicate-commercial medium [9]. Nitrifying bacteria was cultured in Winogradsky medium [10], while probiotic bacteria *B. megaterium* was cultured in a commercial broth medium (Maggi® Indofood, Indonesia) [7].

White shrimp acclimatization

Upon collection, eight days old white shrimps post larvae (PL-8) were stocked in an indoor circular concrete pond (≈20 m^3 volume) at the stocking density of 60 PL/L and 33 ppt initial salinity. To acclimatize shrimp PL at low salinity, salinity reduction was conducted at the rate of 3 ppt/day by mean of daily freshwater addition during nine days acclimatization period, until the salinity level decreased to 5 ppt [11]. After acclimatization, the PL-17 was ready for grow out cultivation at low salinity. The schematic overview of shrimp acclimatization process is presented in Figure 1.

ZWD system installation and conditioning

The installed ZWD system consisted of: (1) rectangular concrete culture pond (6.5 × 2.75 × 0.7 m ≈ 20 m^3 volume) filled with low salinity water (±5 ppt); (2) grained $CaCO_3$, as substrate for nitrifying bacteria and pH buffering agent; (3) aeration line (aerator and air stone) for continuous O_2 supply at the rate of 90 mL/minute; (4) microalgae *C. calcitrans* culture, as live feed source for shrimp, nitrate reducer, and shading effect agent for shrimp culture, (6) nitrifying bacteria culture, to perform nitrification reaction, maintaining ammonium and nitrite in culture water at the acceptable level for shrimp culture, (7) *B. megaterium*, as probiotic bacteria to increase the feed digestibility and shrimp feeding intake [12], (8) feeding tray to administer and control daily feed amount sufficiency, and (9) thermometer, to monitor daily temperature of culture water (Figure 2).

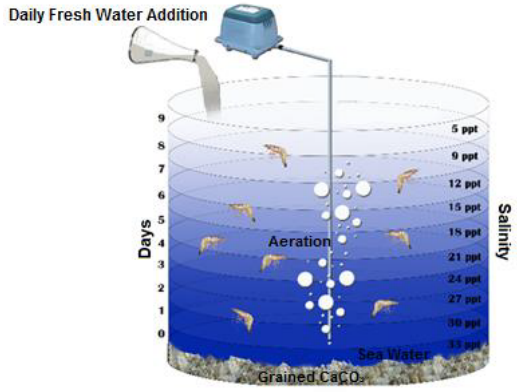

Figure 1: Schematic overview of white shrimp culture acclimatization process.

Conditioning of ZWD system was started by an initial addition of nitrifying bacteria culture, consisting of ammonium oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) at 0.05% v/v (bacterial density of 10^7 CFU/mL) and *B. megaterium* at 0.05% v/v (bacterial density of 10^7 CFU/mL) at low salinity (5 ppt) culture water. 20 gram of NH_4Cl≈1 ppm NH_4^+ was added as ammonium source for the AOB culture. The ammonium reduction by AOB and nitrite reduction by NOB culture were monitored for five days until ammonium and nitrite level decreased to 0.5 ppm. Afterward, microalgae *C. calcitrans* was inoculated at 0.05% v/v (algal density of 10^6 cell/mL).

White shrimp cultivation using ZWD system

PL-17 white shrimp cultivation using ZWD system at low salinity water (5 ppt) was conducted for 70 days in three different stocking densities treatments: (1) stocking density 1: 200 in d/m^3, (2) stocking density 2: 300 in d/m^3, and (3) stocking density 3: 400 in d/m^3. Each treatment was conducted in four replicates. Continuous aeration rate of 47.62-83.33 mL/second was maintained during culture period by mean of six aeration lines (through air diffuser tubing) inside each culture tank. Approximately 2% of total water volume from each tank was siphoned and replaced every day to remove the remaining uneaten feed and shrimp feces. The feeding scheme was modified from Tacon [13]: commercial feed with 40% protein content was delivered five times a day at 06:00, 10:00, 14:00, 18:00 and 23:00. Feed was placed on a feeding tray and monitored frequently to provide information of daily delivered feed accuracy (Table 1). Leftover feed on the tray enables monitoring of shrimp consumption rate, to observe the effect on shrimp size and health condition. Feeding level was adjusted every week based on the measurement of mean body weights and estimation of the shrimp survival and feeding rate. Each parameter contributed and calculated with equation 1:

$$\Sigma\, feed\ (gr) = SD \times MBW \times FR \times SR \quad (1)$$

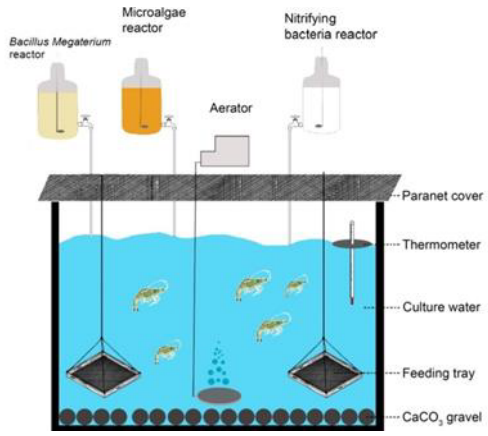

Figure 2: Schematic overview of ZWD system for white shrimp culture (*L. vannamei*).

Shrimp size (gr)	Feeding rate (% of shrimp biomass)	Feeding tray monitoring intervals (hours)
<1	10	3.5
01-Mar	7	3.5
03-May	6.5	2.5
05-Jul	5.5	2
07-Sep	5	2

Table 1: Feeding schedule for white shrimp farming at 25 ± 1°C.

SD: stocking density (individual/tank), MBW: mean body weight (gr), SR: survival rate (%), FR: feeding rate (% of shrimp biomass).

Biological feasibility study

Biological feasibility was assessed based on production performance and water quality analysis during cultivation. Production performance considers survival rate (SR), food conversion ratio (FCR), specific growth rate (SGR), total biomass per tank and shrimp size distribution calculation on each treatment.

Survival rate was calculated using equation 2:

$$SR = Nt/No \times 100\% \quad (2)$$

Where, SR: survival rate, No: initial shrimp number, Nt: final shrimp number, t: culture period (day).

Shrimp specific growth rate was calculated using equation 3:

$$SGR\ (\%/day) = [\ln (W2/W1)/(T2-T1) \times 100] \quad (3)$$

Where, SGR: specific growth rate, W1: initial body weight (g) at time T1 (day), W2: final body weight (g) T2, after T1 (day)

Several physicochemical water quality parameters including dissolved oxygen (DO), pH, ammonium/NH_4^+, nitrite/NO_2^- and nitrate/NO_3^- concentration, were measured and analysed weekly. DO and pH level were measured using DO meter Hach® 40 qd and pH meter Eutech Instruments, respectively. Ammonium/NH_4^+, nitrite/NO_2^- and nitrate/NO_3^- concentration were measured using Nessler, diazotitation, and nitrate HCl methods, respectively [14].

Technical feasibility study

Technical feasibility was assessed based on the production site analysis and operational necessities for shrimp production. The distance of production site to water resource, biophysical condition, land topography and structure, materials supply, market location, accessibility and supporting facilities nearby were considered in production site analysis [15]. On the other hand, materials, equipment and facilities required for cultivation were accounted for operational necessities analysis based on their specification and quantity [16].

Production scheme development

Production scheme plan was developed to produce 1,000 kg shrimp biomass/cycle at each stocking density. The scheme was arranged by identification of operational unit needed for shrimp production at industrial scale. Afterwards, a farm layout using low salinity ZWD system was designed based on the culture performance at each stocking density. The production scheme was then developed based on the real condition in shrimp industry during the study period.

Financial feasibility study

The financial feasibility was analysed based on data collected from surveys and experiments. Before being analysed for financial feasibility, all data were projected to produce 1000 kg shrimps/cycle during 10 years production period. The financial feasibility were analysed based on the investment feasibility which determined by using the net present value (NPV), internal rate of return (IRR), and payback period formula [17]. The formulas are described below:

Net present value (NPV):

$$NPV = \sum_{t=1}^{n} (Bt - Ct)/(1+i)^t \quad (4)$$

Where, Bt: revenue achieve at year t, Ct: production cost spend at year t, i: discount rate (%), t: time (year).

BEP unit produce:

$$BEP = \frac{\text{Fixed cost}}{\text{unitprice} - (\text{variable cost} / \text{amount unit produce})} \quad (5)$$

Unit price were determined from production cost:

$$\text{Unit price} = (\text{fixed cost} + \text{variable cost})/\text{unit produce} \quad (6)$$

Payback period:

$$PBP = t + [(b-c)/(d-c)] \quad (7)$$

where, t: year before present value have the same amount of initial investment, b: initial investment, c: revenue in t year, d revenue at t+1 year

Internal rate of return (IRR):

$$IRR = i_1 + (NPV\ i_1 \times (i_2 - i_1))/(NPVi_1 - NPVi_2) \quad (8)$$

where, i1: discount factor at initial investment, i2: discount factor where NPV ≤ 0

Statistical analysis

All data were subjected to One-way variance analysis (ANOVA); mean differences between treatments were separated using Duncan Multiple Range Test at P > 0.05, using SPSS version 17.

Result and Discussion

Biological feasibility analysis

Production performance analysis: Production performance which is indicated by several biological parameters during 70 days cultivation at three different stocking densities are presented in Table 2. The highest survival rate of 93.52 ± 3.32% was obtained from the 200 in d/m³ stocking density, followed by 300 in d/m³ stocking density (79.11 ± 5.81%) and 400 in d/m³ stocking density (70.59 ± 6.15%), ($p<0.05$). The specific growth rate and FCR of all treatments were not significantly different and it ranged between 4.22 ± 0.24%-4.64 ± 0.14% and 1.05 ± 0.07-1.14 ± 0.14, respectively. Different densities among treatments affected significantly the total shrimp biomass harvested at the end of production period. The highest total biomass of 44.13 ± 4.44

Parameters		Stocking densities (ind/m³)		
		200	300	400
SR (%)		93.52 ± 3.32[a]	79.11 ± 5.81[b]	70.59 ± 6.15[b]
SGR (%)		4.64 ± 0.14[a]	4.22 ± 0.24[a]	4.40 ± 0.25[a]
FCR		1.05 ± 0.07[a]	1.06 ± 0.08[a]	1.14 ± 0.14[a]
Total Biomass (kg)		27.7 ± 1.55[a]	36.25 ± 3.01[b]	44.13 ± 4.44[c]
Size Distribution (%)	100-150 in d/kg	86.77[a]	91.93[ab]	95.85[b]
	150-250 in d/kg	13.23[a]	8.07[ab]	4.15[b]

*Means of values with same superscript along rows are significantly different ($p<0.05$).

Table 2: White shrimp production performances of ZWD system among treatments.

kg was obtained from 400 in d/m³ stocking density, followed by 300 in d/m³ (36.25 ± 3.01 kg) and 200 in d/m³ stocking densities (27.75 ± 1.55 kg) ($p<0.05$).

By stocking shrimp at a higher density, higher percentage of shrimps which sized between 100-150 shrimps/kg was also harvested. Proportion of harvested shrimp with size distribution between 100-150 shrimps/kg at 400, 300, 200 in d/m³ stocking densities was 95.85%, 91.93%, 86.77%, respectively. In contrast, higher percentage of shrimps with lower size distribution (150-250 shrimps/kg) was obtained at a lower stocking density (Table 3).

It is shown that the higher stocking density (300 in d/m³ and 400 in d/m³) produced significantly lower survival rate compared to the low stocking density (200 in d/m³) (Table 4). This is attributable to the environmental stress due to space competition and crowded effect caused by the high shrimp population present [18,19]. It has been suggested that competition increases cannibalistic behavior of shrimps, particularly during the molting period [20,21]. Besides, high stocking density causes higher risk of water quality deterioration, pathogen spreading, and cannibalism due to competition for food and space [19]. Although high stocking densities resulted in decreased survival rates, a more homogenous niche occupancy could have been obtained and hence the more homogenous feed access chance may have allowed the survived shrimp to reach a higher final body weight at the end of the culture period [22]. No significant differences in FCR value were observed between the high and low stocking densities, indicating that the feed conversion efficiency was still acceptable at high stocking densities, despite their lower survival rates.

In general all biological parameters were in the acceptable condition for shrimp production. All treatments resulted in survival rate of 70-93% and productivities of 1.39-2.21 kg/m³ within 70 days culture period, which were comparable to an intensive conventional culture method in Indonesia (average survival rate of 81% and productivity of 1.72-2.0 kg/m³ within 100-120 days culture period at a stocking density of 60-300 in d/m³) [23-25]. Based on the following comparison between ZWD system and conventional system performances (Table 3), the use of ZWD system in all stocking densities was biologically feasible.

Parameter	ZWD System (5 Rpt salinity)			Conventional System		
				5 Rpt salinity [23]	Intensive [24]	Intensive [25]
Stocking Density (ind/m³)	200	300	400	60	99	300
SR (%)	93.52	79.11	70.59	85	81	81
FCR	1.05	1.06	1.14	1.3	1.37	1.6
Production period (day)	70	70	70	100	120	120
Harvest Size (ind/kg)	100	100	100	40	50	50
Productivity (kg/m²)	1.39	1.81	2.21	1.47	1.72	2

Table 3: Performance comparison of ZWD and conventional shrimp culture systems.

Parameter	SD1 (200 ind/m³)	SD2 (300 ind/m³)	SD3 (400 ind/m³)	Range Tolerance
pH	7.61-8.27	7.71-8.36	7.27-8.38	6.5-8.3 [30]
DO (mg/L)	4.90-8.50	5.00-8.00	5.60-7.80	> 4 mg/L [31]
Temperature (°C)	29.3-30.1	29.8-30.1	30.4-30.9	24-32°C [31]
NH_4^+ (mg/L)	0-0.5	0-3.0	0-3.0	≤3.95 mg/L [5]
NO_2^- (mg/L)	0-5.0	0.2-3.0	0.2-5.0	≤25.7 mg/L [26]
NO_3^- (mg/L)	5.0-35.0	5.0-30.0	5.0-25.0	≤232 mg/L [27]

Table 4: Water quality parameters of experimental units during 70 days culture period.

Water quality parameter analysis: Several culture physicochemical parameters measured during 70-day-culture period are presented in Table 4. In general, there were no significant difference on water quality measured among treatments ($p>0.05$). Acceptable water quality parameters were obtained among treatments during 70 days culture period. Temperature, dissolved oxygen, pH level, ammonium (NH_4^+-N), nitrite (NO_2^--N), and nitrate (NO_3^--N) were ranged between 29.3-30.9°C, 4.90-8.50 mg/L, 7.27-8.38, 0–3.0 mg/L, 0.2–5.0, and 5.0-35.0 mg/L, respectively. The ammonium (≤3.95 mg/L), nitrite (≤25.7 mg/L), nitrate (≤232 mg/L) concentration was still within tolerance range of hite shrimp culture [5,26,27]. The similar values of most water quality parameters, especially pH level and ammonium, nitrite and nitrate concentration between treatments were attributable to the use of ZWD system for all stocking densities, which emphasizes on the nutrient (carbon and nitrogen) cycle manipulation [7]. In this system, ammonium produced from organic decomposition by heterotrophic bacteria, such as added *B. megaterium* inoculum, can be directly converted to nitrite by ammonium oxidizing bacteria from nitrifying bacteria consortium. On the other hand, nitrite availability enables nitrite oxidizing bacteria to shift chemical equilibrium of the nitrification reaction by nitrate production. The produced nitrate can be used by photoautotrophic microalgae *C. calcitrans* [7]. The use of grained $CaCO_3$ was able to stabilize the pH level due to its slow release of carbonate ion (CO_3^{2-}) that can balance the acidification as the result of organic matter decomposition and continuous nitrification processes [28-31].

Technical Feasibility Analysis

Production site analysis

Selection of suitable area for ZWD system implementation as well as production requirements are crucial to ensure that the technology can be accepted and successfully implemented. Farmer selection was considered to be the most important aspect. By considering several criteria as follows: quality and quantity of water sources, land topography, land structures, accessibility, availability of production infrastructure, such as electricity sources, seed producers, and distance to an aquaculture government research facility, it is suggested that the north coastal areas of East Java Province, such as Tuban, Lamongan, Gresik, Sidoarjo, Pasuruan, Probolinggo, and Situbondo were suitable for shrimp urban aquaculture using ZWD system. All of these areas fulfill the following criteria:

1. Located close to sea water sources.
2. Provide suitable physical condition for shrimp growth (temperature, humidity, and light intensity). Temperature and humidity in dry season ranged between 22-34°C and 50-86%, respectively [32,33].
3. Land topography is relatively contour less, provides easiness to build a farm on the terrain and less land clearing cost.
4. Located close to domestic market in the main cities of East Java province: Surabaya and Lamongan. They have the most cold storage companies (19.8%) and fish processing units (23.7%) compared to total available units in Indonesia [34]. By number, there are 59 fish processing units in East Java Province [35].
5. Free from any social conflict.

6. Receive government supports in form of many aquaculture research institutions.

Production requirements analysis

As a new approach of shrimp production using ZWD system, more culture control is necessary, compared to conventional culture system. Control was started from the preparation, conditioning and operating of the system to harvesting. To help achieve this control, several specified components are required in the shrimp farm, such as: shrimp seeds, feed, water sources (sea water and fresh water), probiotic and microalgae (Table 5). All of these components were adjusted to produce equal quantity of shrimps (1000 kg) from each stocking density. Several specified components and its quantity were presented on Tables 6 and 7. According to Table 8, 200 in d/m^3 stocking density occupies the widest area and more production ponds compared to 300 and 400 in d/m^3 stocking densities, while 400 in d/m^3 stocking density occupies the least area and fewer production ponds. Therefore, 400 in d/m^3 stocking density is considered to be the most efficient treatment as it needs the least facilities investment among all stocking densities.

No	Factors	Specifications
1	Shrimp Seeds	Post larvaes (PL8-18 days) are already acclimatizated to low salinity water, healthy, active, relatively homogenous in size and *specific pathogen free* (SPF).
2	Feed	Consist of ≥30% protein, >5% fat and ≤4% fiber. Size and type of feed (crumble or pellet) is adjusted to feeding management table.
3	Probiotic Bacteria	Consist of: 1. Chemolitotrophic bacteria, ammonium oxidizing bacteria and nitrite oxidizing bacteria, to maintain inorganic nitrogen concentration in water. 2. Heterotrophic bacteria, *Bacillus megaterium,* for organic compound breakdown and increase shrimp aRpetite.
4	Water Sources	Has been treated through sedimentation, filtration, and disinfection. Has the following physicochemical parameters: temperature 24-32°C, salinity ± 5 Rpt, dissolved oxygen (DO) >4 mg/L, NH_4^+<0.5 mg/L, NO_2^-<0.1 mg/L, and NO_3^-<1000 mg/L

Table 5: Components specification required for low salinity white shrimp culture in ZWD system.

Materials Requirement	SD1 (200 ind/m^3)	SD2 (300 ind/m^3)	SD3 (400 ind/m^3)
White Shrimp Seed (individual)	148,000	165,000	184,000
Shrimp Feed (kg)	1,050	1,060	1,140
Sea water (m^3)	111	84	69

Table 6: Materials required among treatments for low salinity white shrimp culture in ZWD system.

No	Production Facilities	Specifications
1	Production Ponds	A rectangular concrete pond (size 5 × 4 × 1.2 m, volume 20 m^3), an aeration device, an inlet pipe, an outlet pipe (central drain), tarpaulin coverage (for water temperature stability).
2	Reservoir Tank	A rectangular concrete pond (size 5 × 5 × 1.2 m), an aeration device, an inlet pipe, an outlet pipe (central drain), a tarpaulin coverage (for water temperature stability and avoid external organic input).
3	Acclimatization Tank	An indoor rectangular concrete pond (size 3 × 1 × 1.2 m), an aeration device, an inlet pipe, an outlet pipe (central drain).
4	Aeration Devices	A dynamo motor, a blower, PVC pipes, regulators, diffusers. Units are placed beside production ponds. Dynamo motor and blower are locked inside to avoid any disturbance.
5	Electricity Devices	A generator, cables, and a panel.
6	Algae Ponds	Circular fiber ponds with size (D 1.25 × h 0.6 m), equiRped with aeration device.
7	Nitrifying Bacteria Ponds	Circular fiber ponds with size (D 1.25 × h 0.6 m), covered and equiRped with aeration device.
8	*B. megaterium* Ponds	A rectangular plastic container (0.5 × 0.2 m), covered and equiRped with aeration device.
9	Pumps	A submerged pump (circulate treated water from sedimentation ponds to culture ponds), a pump (circulate well water from culture ponds to treatment ponds).
10	Recirculating Aquaculture System	Water treatment components: a sedimentation pond (5 × 3 × 1.2 m) with a physical filter, 2 protein skimmers (70 L), carbon filter (100 L), and a biofilter pond (5 × 5 × 1.2 m) with inoculated nitrifying bacteria on $CaCO_3$ (gravel).

Table 7: Facilities specification required for low salinity white shrimp culture in ZWD system.

Production Facilities Requirements	SD1 (200 in d/m^3)	SD2 (300 in d/m^3)	SD3 (400 in d/m^3)
Land purchase (m^2)	1250	1125	1000
Production ponds (5 × 4 × 1.2 m)	37	28	23
Tarpaulin (m^2)	740	560	460
Reservoir ponds (5 × 5 × 1.2 m)	2	2	2
Acclimatization Ponds (3 × 1 × 1.2 m)	2	2	2
Algae ponds (D1.25 × h0.6 m)	2	2	2
Nitrifying bacteria ponds (D1.25 × h0.6 m)	1	1	1
B. megaterium container(0.5 × 0.2 m)	2	2	2
Sedimentation tank (5 × 3 × 1.2 m)	1	1	1
Protein skimmer (70 L)	1	1	1
Biofilter tank (5 × 5 × 1.2 m) ($CaCO_3$ gravel)	2	2	2
Submerged pump	2	2	2
Vacuum sealer	1	1	1
Freezer box	2	2	2
Electricity devices (generator, cable, and panel)	1	1	1
Aeration pack (dynamo motor, blower, hoses)	1	1	1

Table 8: Facilities requirements among treatments for low salinity white shrimp culture using ZWD system.

Production scheme development

Production scale estimation: Production estimation of low salinity white shrimp culture using ZWD system was assumed to produce 1000 kg shrimp/cycle for 3 months (preparation, production, and marketing). Harvested shrimps were distributed to domestic market segments, cold storage companies, and shrimp processing units surrounding East Java Province. The demand for fresh harvested shrimp is approximately 15-20 Ton/day in East Java Province [36]. In this study, the shrimp product was widely accepted for domestic market segments because the harvested shrimps were at the size distribution of 100 shrimps/kg, acceptable to the demanded size in Surabaya and Indonesia (100 shrimps/kg, 80 shrimps/kg, 70 shrimps/kg, to 60 shrimps/kg) [37].

Production scheme: Based on real production scheme in the shrimp farm documented during this study, a model of production scheme considering minimum operation units and human resources was arranged (Figure 1). To operate low salinity white shrimp culture using ZWD system, the production scheme was arranged into six units

1. Purchasing and inventory unit, for ordering and purchasing raw materials
2. Waste and water treatment unit, for recycling input and waste water
3. Rearing unit, to rear shrimp from acclimatization stage until harvest time
4. Harvesting unit, to conduct shrimp harvest from a pond and post-harvest treatment
5. Marketing and distribution unit, to distribute fresh shrimp
6. Transaction and archive unit, to record production result and transaction history.

To operate the mentioned scheme, one or two technicians and one tank operator are needed to produce 1000 kg/cycle of fresh shrimps. Considering the small production scale, the recruited human resources must be able to multitask in order to maintain production efficiency and sustainability. ZWD system facilities include a controllable small pond that provides easiness to be cleaned and harvested regularly, which simplify the labour works. Workload are distributed into several positions consist of a technician, a pond operator and an owner. Technician is responsible for assisting operator and technical matters related with water treatment and rearing process, including siphoning, feeding, shrimp weight sampling and harvesting. Pond operator is responsible to lead production operational and coordinate technician to assist production. Meanwhile, the owner is responsible to pay the worker's salary, to create financial report, and to direct and build company networks.

Farm lay out design: Shrimp farm lay out was designed by considering facilities required and production scheme. Its dimension is planned by considering the product specification (fresh shrimp size of 100 shrimps/kg), culture period (70 days) and production scale (1000 kg/cycle). According to the presented lay out (Figure 2), 200 in d/m^3 stocking density has the highest requirement of production area as it needs the highest number of pond, 37 ponds, compared to 300 in d/m^3 stocking density (28 ponds) and 400 in d/m^3 stocking density (23 ponds).

Financial feasibility analysis: Financial feasibility of the shrimp production at low salinity using ZWD system was analysed based on the equations described in section II.7, with the following facts and assumptions

1. One production cycle runs for 70 days.
2. Fresh shrimp worth IDR 60.000/kg.
3. Seed stocking density of 200 in d/m^3, 300 in d/m^3 and 400 in d/m^3.
4. Average survival rate (SR) at 200, 300, 400 in d/m^3 stocking densities of 93.52%, 79.11% and 70.59%, respectively.
5. Average harvested biomass per 20 m^3 pond at 200, 300, 400 in d/m^3 stocking densities of 27.75 kg, 36.25 kg and 44.13 kg, respectively.
6. Average feed conversion ratio (FCR) at 200, 300, 400 in d/m^3 stocking densities 1.05, 1.06, and 1.14, respectively.
7. Operational costs per cycle include: shrimp seed, feed, labor, algae and probiotic, electricity, sea water, chemicals and disinfectant, harvesting, packaging and distribution, and depreciation.
8. Investment costs include: land, buildings, production ponds, acclimatization ponds, algae ponds, reservoir ponds, nitrifying bacteria ponds, container for *B. megaterium*, sedimentation ponds, protein skimmer, bio-filter ponds, electricity devices, aeration devices, tarpaulin, pumps, a vacuum sealer, and a freezer box.
9. Estimated area required for 200 in d/m^3, 300 in d/m^3, and 400 in d/m^3 stocking densities of 1250 m^2, 1125 m^2 and 1000 m^2, respectively.

Operational costs calculation: The total operational cost to produce 1000 kg/cycle using ZWD system can be seen in Tables 9-11. The 200 in d/m^3 stocking density has the highest operational cost, with total operational cost of approximately Rp 49,087,750, followed by 400 and 300 in d/m^3 stocking densities which cost Rp 40,227,125 and Rp 39,494,625, respectively. Among all treatments, the highest operational

Operational Costs	Quantity	Unit	Price/unit	Total Cost (IDR)
Shrimp Seeds	1,48,000	Individual	Rp 30	Rp 4,440,000
Feed (FCR 1.05)	1,050	kg	Rp 16,000	Rp 16,800,000
Labour Costs (Operator + 2 Technician)	3	salary/ month	Rp 5,500,000	Rp 16,500,000
Electricity		kWH		Rp 2,590,000
Sea Water	22.2	Tank (5,000 L)	Rp 200,000	Rp 4,440,000
Algae and Probiotics	1	Pack	Rp 400,000	Rp 400,000
Chemicals and Disinfectants	1	Pack	Rp 370,000	Rp 370,000
Harvesting Cost	1	Pack	Rp 500,000	Rp 500,000
Packaging and delivery Cost	1	Pack	Rp 500,000	Rp 500,000
Depreciation Cost/Cycle	1	Pack	Rp 2,547,750	Rp 2,547,750
Total Production Cost/Cycle				Rp 49,087,750
Production Cost/kg shrimp				Rp 49,088
Revenue/Cycle (1000 kg × 50,000)				Rp 60,000,000
Profit/Cycle = Total Revenue - Total Production Cost				Rp 10,912,250
Profit/Month				Rp 3,637,417
Profit/Pond				Rp 474,446
Profit/Kg Shrimp				Rp 10,912
BEP/Kg Shrimp				Rp 4,498
Revenue	Quantity	Unit	Price/unit (IDR)	Total Revenue
White Shrimp Size 100	1,000	kg	60,000	6,00,00,000

Table 9: Estimated production cost to produce 1000 kg shrimps/cycle at 200 ind/m^3 stocking density.

Citation: Muhammad H, Situmorang ML, Djohan YA, Aditiawati P, Suantika G (2016) Biological, Technical, and Financial Feasibilities Study of Zero Water Discharge (ZWD) System Application in Low Salinity White Shrimp (*Litopenaeus vannamei* Boone) Urban Aquaculture, Study Case: Gresik District, East Java, Indonesia. J Fisheries Livest Prod 4: 197. doi: 10.4172/2332-2608.1000197

Operational Costs	Quantity	Unit	Price/unit (IDR)	Total Cost (IDR)
Shrimp Seeds	1,68,000	Individual	Rp 30	Rp 5,040,000
Feed (FCR 1.06)	1,060	kg	Rp 16,000	Rp 16,960,000
Labour Costs (Operator + Technician)	3	salary/ month	Rp 4,000,000	Rp 12,000,000
Electricity		kWH		Rp 1,960,000
Sea Water	16.8	Tank (5,000 L)	Rp 200,000	Rp 3,360,000
Algae and Probiotics	1	Pack	Rp 400,000	Rp 400,000
Chemicals and Disinfectants	1	Pack	Rp 280,000	Rp 280,000
Harvesting Cost	1	Pack	Rp 500,000	Rp 500,000
Packaging and distribution Cost	1	Pack	Rp 500,000	Rp 500,000
Depreciation Cost/Cycle	1	Pack	Rp 2,494,625	Rp 2,494,625
Total Production Cost/Cycle				Rp 43,494,625
Production Cost/kg shrimp				Rp 43,495
Revenue/Cycle (1000 kg × 50,000)				Rp 60,000,000
Profit/Cycle=Total Revenue-Total Production Cost				Rp 16,505,375
Profit/Month				Rp 5,501,792
Profit/Pond				Rp 717,625
Profit/Kg Shrimp				Rp 16,505
BEP/Kg Shrimp				Rp 2,635
Revenue	Quantity	Unit	Price/unit (IDR)	Total Revenue
White Shrimp Size 100	1,000	kg	60,000	6,00,00,000

Table 10: Estimated production cost to produce 1000 kg shrimps/cycle at 300 ind/m³ stocking density.

Operational Costs	Quantity	Unit	Price/unit	Total Cost (IDR)
Shrimp Seeds	1,84,000	Individual	Rp 30	Rp 5,520,000
Feed (FCR 1.14)	1,140	kg	Rp 16,000	Rp 18,240,000
Labour Costs (Operator + Technician)	3	salary/ month	Rp 4,000,000	Rp 12,000,000
Electricity		kWH		Rp 1,610,000
Sea Water	13.8	Tank (5,000 L)	Rp 200,000	Rp 2,760,000
Algae and Probiotics	1	Pack	Rp 400,000	Rp 400,000
Chemicals and Disinfectants	1	Pack	Rp 230,000	Rp 230,000
Harvesting Cost	1	Pack	Rp 500,000	Rp 500,000
Packaging and distribution Cost	1	Pack	Rp 500,000	Rp 500,000
Depreciation Cost/Cycle	1	Pack	Rp 2,467,125	Rp 2,467,125
Total Production Cost/Cycle				Rp 44,227,125
Production Cost/kg shrimp				Rp 44,227
Revenue/Cycle (1000 kg × 50,000)				Rp 60,000,000
Profit/Cycle = Total Revenue - Total Production Cost				Rp 15,772,875
Profit/Month				Rp 5,257,625
Profit/Pond				Rp 685,777
Profit/Kg Shrimp				Rp 15,773
BEP/Kg Shrimp				Rp 2,804
Revenue	Quantity	Unit	Price/unit (IDR)	Total Revenue
White Shrimp Size 100	1,000	kg	60,000	6,00,00,000

Table 11: Estimated production cost to produce 1000 kg shrimps/cycle at 400 ind/m³ stocking density.

cost were contributed by feed cost (34-41%) and followed by labor cost (27-34%) (Figure 3). High operational cost of 200 in d/m³ stocking density was due to more labor cost required to handle extra ponds. The highest profit was achieved by 300 in d/m³ stocking density with profit of Rp 16,505,375, followed by 400 and 200 in d/m³ stocking density with profit of Rp 15,772,875 and Rp 10,912,250, respectively.

Investment cost: Investment costs calculations are presented in Tables 12-14. Again, 200 in d/m³ stocking density has the highest investment costs of approximately Rp 443,520,000, followed by 300 and 400 in d/m³ stocking density (Rp 358,080,000 and Rp 318,230,000), respectively. The highest component contribute to the investment costs are production ponds cost (36-42%) and land purchasing (21-24%) (Figure 4). Clearly, high investment cost for 200 in d/m³ stocking density was due to higher number of ponds needed for production.

Financial projection: Financial projections were calculated to predict the break event point. Profit was calculated by subtracting the total revenue with production cost. Assumed that there are four production cycles per year, in which 1000 kg shrimps are produced per cycle with duration of three months, in one year the farm will produce 4000 kg of fresh shrimp with a total revenue of Rp 240,000,000. Financial projection for 200, 300, 400 in d/m³ stocking densities are presented in Tables 15-17. The most efficient treatment with the lowest production cost was achieved in 400 in d/m³ stocking density with production cost per cycle of Rp 40,227,125 or Rp 160,908,500 per year and the highest profit of Rp 79,091,500. The 400 and 300 in d/m³ stocking densities treatment will achieve a payback period after four years of operation, while 200 in d/m³ stocking density it will be achieved after ten years operation Figures 5 and 6.

Financial ratio calculation: Financial ratios were calculated to assess the financial feasibility of ZWD system. Financial ratio analyses consist of NPV, IRR, B/C Ratio, and Pay Back Period (PBP). Based on financial analysis, the project is financially feasible if the NPV positive, the IRR value is higher than discount factor, and the B/C ratio value is higher than 1 [16,38]. The financial ratio calculations are presented in Table 18. It can be clearly seen that 300 and 400 in d/m³ stocking densities were financially feasible as they resulted in positive NPV (approximately Rp 47,593,537 and Rp 69,439,955), IRR value that higher than discount factor (approximately 13.40% and 15.49%), and B/C ratio higher than 1 (around 1.13 and 1.22). In contrast, 200 in d/m³ stocking densitiy was not financially feasible due to its negative NPV value (around Rp -175,315,390) and IRR value that is lower than discount factor (lower than 10%), with B/C ratio less than 1 [38].

Conclusion

Based on the results of this current study, it can be concluded that the implementation of low salinity ZWD system for urban shrimp aquaculture production at high stocking density of 300 in d/m³ and 400 in d/m³ was feasible to be applied in Gresik on the north-coastal area of East Java Province, Indonesia.

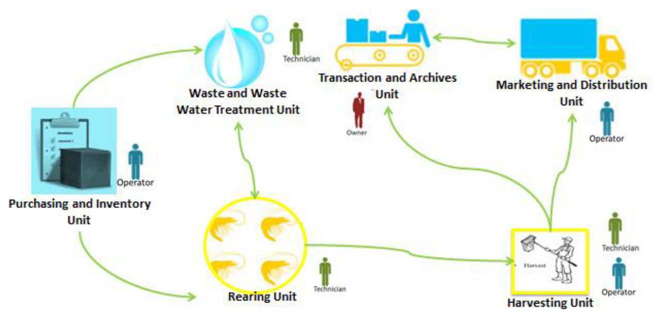

Figure 3: Flow of Production Scheme: Units and human resources needed to produce 1000 kg shrimps/cycle.

Capital Costs	Quantities	Units	Price/unit	Total
Land Purchase (1,057 m²)	1	Package	Rp 105,700,000	Rp 105,700,000
Buildings	1	unit	Rp 70,000,000	Rp 70,000,000
Production Tank (Concrete Pond, 5 × 4 × 1.2 m)	37	Package	Rp 5,000,000	Rp 185,000,000
Reservoir Tank (Concrete Pond, 5 × 5 × 1.2)	2	Package	Rp 6,250,000	Rp 12,500,000
Acclimatization Tank (Concrete Pond, 3 × 1 × 1.2 m)	2	Package	Rp 1,500,000	Rp 3,000,000
Algae Tank (Circular fiber, 1.25 × t0.6)	2	Package	Rp 1,250,000	Rp 2,500,000
Nitrifying Bacteria Tank (Circular fiber, 1.25 × t0.6)	1	Package	Rp 1,250,000	Rp 1,250,000
B. megaterium reactor (cylindrical fiber, 0.5 t × 0.2)	2	Package	Rp 250,000	Rp 500,000
Sedimentation tank (concrete pond, 5 × 3 × 1.2)	1	Package	Rp 6,000,000	Rp 6,000,000
Protein Skimmer (Cylindrical PVC, 70 L)	1	Package	Rp 5,000,000	Rp 5,000,000
Biofilter (concrete pond, include CaCO3, 5 × 5 × 1.2 m)	2	Package	Rp 7,500,000	Rp 15,000,000
Submerged Pump	2	Package	Rp 2,500,000	Rp 5,000,000
Tarpaulin	740	m²	Rp 5,500	Rp 4,070,000
Vacuum Sealer	1	unit	Rp 1,000,000	Rp 1,000,000
Freezer Box	2	unit	Rp 3,500,000	Rp 7,000,000
Electricity Installation (Generator, cable, and panel)	1	unit	Rp 10,000,000	Rp 10,000,000
Aeration pack (Dynamo, blower, hoses)	1	set	Rp 10,000,000	Rp 10,000,000
Total Capital Invested				Rp 443,520,000

Table 12: Estimated investment cost to produce 1000 kg shrimps/cycle at 200 ind/m³ stocking density.

Capital Costs	Quantities	Units	Price/unit	Total
Land Purchase (800 m²)	1	Package	Rp 80,000,000	Rp 80,000,000
Buildings	1	unit	Rp 70,000,000	Rp 70,000,000
Production Ponds (Concrete Pond, 5 × 4 × 1.2 m)	28	Package	Rp 5,000,000	Rp 140,000,000
Reservoir Tank (Concrete Pond, 5 × 5 × 1.2)	1	Package	Rp 6,250,000	Rp 6,250,000
Acclimatization Tank (Concrete Pond, 3 × 1 × 1.2 m)	2	Package	Rp 1,500,000	Rp 3,000,000
Algae Ponds (Circular fiber, 1.25 × t0.6)	2	Package	Rp 1,250,000	Rp 2,500,000
Nitrifying Bacteria Tank (Circular fiber, 1.25 × t0.6)	1	Package	Rp 1,250,000	Rp 1,250,000
B. megaterium reactor (cylindrical fiber, 0.5t × 0.2)	2	Package	Rp 250,000	Rp 500,000
Sedimentation tank (concrete pond, 5 × 3 × 1.2)	1	Package	Rp 6,000,000	Rp 6,000,000
Protein Skimmer (Cylindrical PVC, 70 L)	1	Package	Rp 5,000,000	Rp 5,000,000
Biofilter (concrete pond, include $CaCO_3$, 5 × 5 × 1.2 m)	1	Package	Rp 7,500,000	Rp 7,500,000
Submerged Pump	2	Package	Rp 2,500,000	Rp 5,000,000
Tarpaulin	560	m²	Rp 5,500	Rp 3,080,000
Vacuum Sealer	1	unit	Rp 1,000,000	Rp 1,000,000
Freezer Box	2	unit	Rp 3,500,000	Rp 7,000,000
Electricity Installation (Generator, cable, and panel)	1	unit	Rp 10,000,000	Rp 10,000,000
Aeration pack (Dynamo, blower, hoses)	1	set	Rp 10,000,000	Rp 10,000,000
Total Biaya Investasi				Rp 358,080,000

Table 13: Estimated investment cost to produce 1000 kg shrimps/cycle at 300 ind/m³ stocking density.

Capital Costs	Quantities	Units	Price/unit	Total
Land Purchase (657 m²)	1	Package	Rp 65,700,000	Rp 65,700,000
Buildings	1	unit	Rp 70,000,000	Rp 70,000,000
Production Tank (Concrete Pond, 5 × 4 × 1.2 m)	23	Package	Rp 5,000,000	Rp 115,000,000
Reservoir Tank (Concrete Pond, 5 × 5 × 1.2)	1	Package	Rp 6,250,000	Rp 6,250,000
Acclimatization Tank (Concrete Pond, 3 × 1 × 1.2m)	2	Package	Rp 1,500,000	Rp 3,000,000
Algae Tank (Circular fiber, 1.25 × t0.6)	2	Package	Rp 1,250,000	Rp 2,500,000
Nitrifying Bacteria Tank (Circular fiber, 1.25 × t0.6)	1	Package	Rp 1,250,000	Rp 1,250,000
B. megaterium reactor (cylindrical fiber, 0.5t × 0.2)	2	Package	Rp 250,000	Rp 500,000
Sedimentation tank (concrete pond, 5 × 3 × 1.2)	1	Package	Rp 6,000,000	Rp 6,000,000
Protein Skimmer (Cylindrical PVC, 70 L)	1	Package	Rp 5,000,000	Rp 5,000,000
Biofilter (concrete pond, include CaCO3, 5 × 5 × 1.2 m)	1	Package	Rp 7,500,000	Rp 7,500,000
Submerged Pump	2	Package	Rp 2,500,000	Rp 5,000,000
Tarpaulin	460	m²	Rp 5,500	Rp 2,530,000
Vacuum Sealer	1	unit	Rp 1,000,000	Rp 1,000,000
Freezer Box	2	unit	Rp 3,500,000	Rp 7,000,000
Electricity Installation (Generator, cable, and panel)	1	unit	Rp 10,000,000	Rp 10,000,000
Aeration pack (Dynamo, blower, hoses)	1	set	Rp 10,000,000	Rp 10,000,000
Total Investment Cost				Rp 318,230,000

Table 14: Estimated investment cost to produce 1000 kg shrimps/cycle at 400 ind/m³ stocking density.

Citation: Muhammad H, Situmorang ML, Djohan YA, Aditiawati P, Suantika G (2016) Biological, Technical, and Financial Feasibilities Study of Zero Water Discharge (ZWD) System Application in Low Salinity White Shrimp (*Litopenaeus vannamei* Boone) Urban Aquaculture, Study Case: Gresik District, East Java, Indonesia. J Fisheries Livest Prod 4: 197. doi: 10.4172/2332-2608.1000197

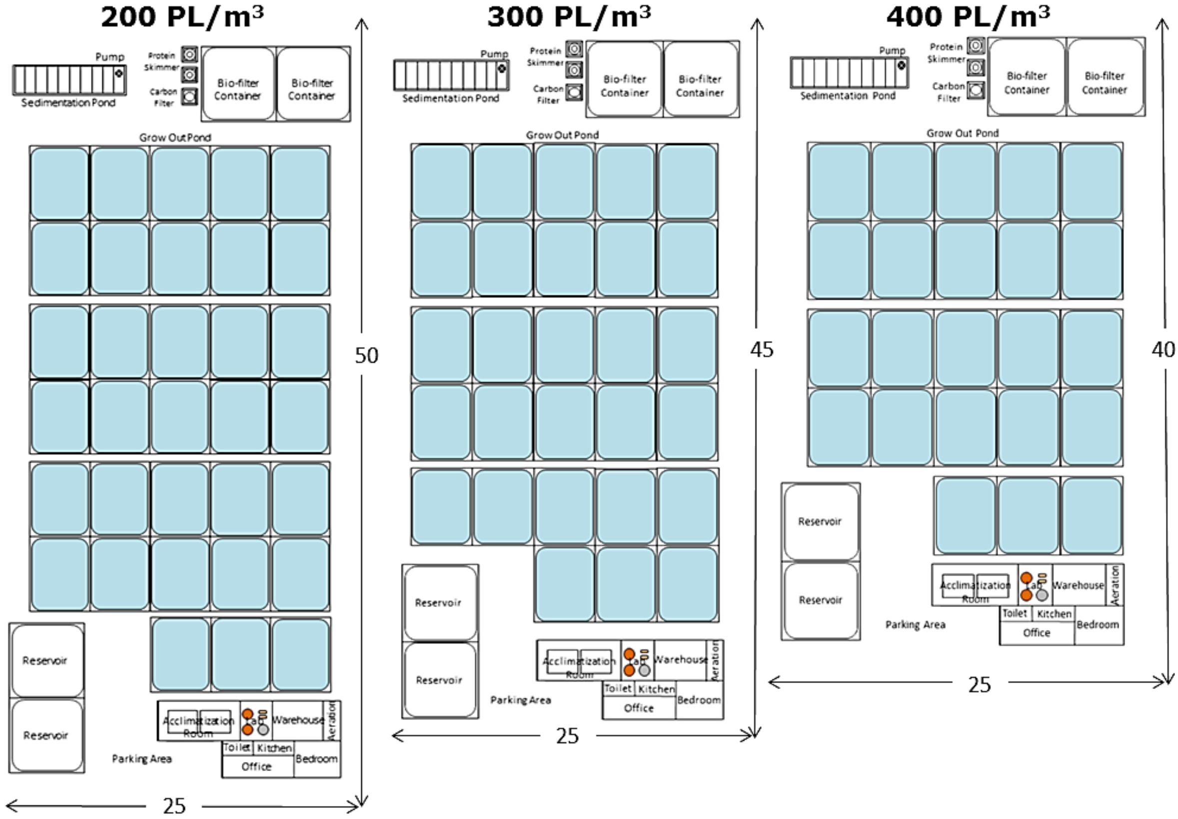

Figure 4: Farm layout of white shrimpculture using low salinity ZWD system at three different stocking densities.

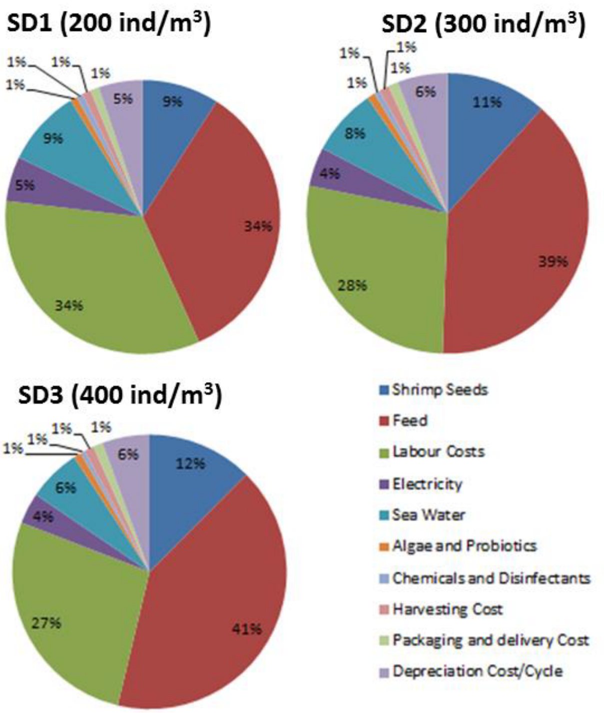

Figure 5: Diagram of investment cost components percentage among different stocking densities to produce 1000 kg shrimps/cycle using low salinity ZWD system.

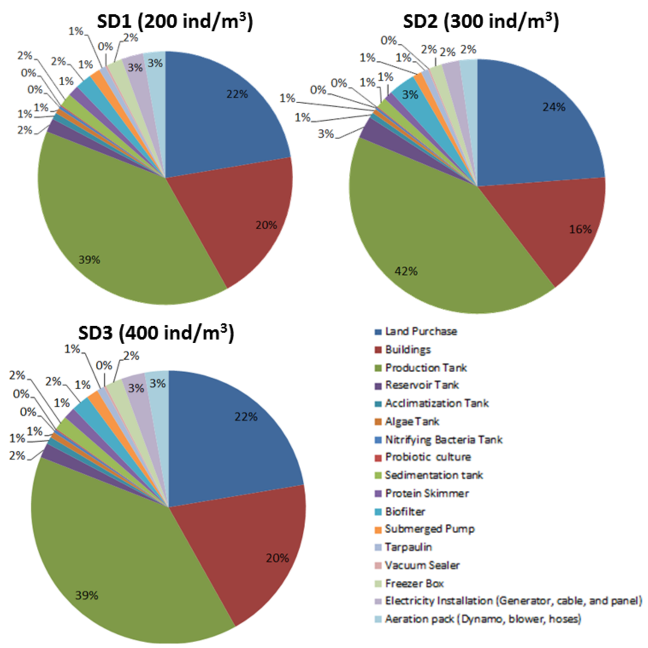

Figure 6: Diagram of production cost components percentage among different stocking densities to produce 1000 kg shrimp/cycle using low salinity ZWD system.

Years	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Income											
Fresh shrimp		4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
Shrimp price			Rp 60,000	Rp 60,000	Rp 60,000	Rp 60,000	Rp 60,000	Rp 60,000	Rp 60,000	Rp 60,000	Rp 60,000
Total income			Rp 240,000,000	Rp 240,000,000	Rp 240,000,000	Rp 240,000,000	Rp 240,000,000	Rp 240,000,000	Rp 240,000,000	Rp 240,000,000	Rp 240,000,000
Expenses											
Feed expenses	Rp 443,520,000										
variable Expences		Rp 186,160,000	Rp 186,160,000	Rp 186,160,000	Rp 186,160,000	Rp 186,160,000	Rp 186,160,000	Rp 186,160,000	Rp 186,160,000	Rp 186,160,000	Rp 186,160,000
Depreciation		Rp 10,191,000	Rp 10,191,000	Rp 10,191,000	Rp 10,191,000	Rp 10,191,000	Rp 10,191,000	Rp 10,191,000	Rp 10,191,000	Rp 10,191,000	Rp 10,191,000
Total Expenses	Rp 443,520,000	Rp 196,351,000	Rp 196,351,000	Rp 196,351,000	Rp 196,351,000	Rp 196,351,000	Rp 196,351,000	Rp 196,351,000	Rp 196,351,000	Rp 196,351,000	Rp 196,351,000
Profitloss	Rp (443,520,000)	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000
Net income	Rp (443,520,000)	Rp (399,871,000)	Rp (356,222,000)	Rp (312,573,000)	Rp (268,924,000)	Rp (225,275,000)	Rp (181,626,000)	Rp (137,977,000)	Rp (94,328,000)	Rp (50,679,000)	Rp (7,030,000)

Table 15: Shrimp product financial projection of 200 ind/m^3 stocking density using low salinity ZWD system to produce 1000 kg shrimp during 70 days culture period.

Years	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Income											
Fresh shrimp		4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
Shrimp price			Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000
Total income			Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000
Expenses											
Feed expenses	Rp 318,230,000										
variable Expences		Rp 151,040,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000
Depreciation		Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000
Total Expenses	Rp 318,230,000	Rp 160,908,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000
Profitloss	Rp (318,230,000)	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000	Rp 43,649,000
Net income	Rp (318,230,000)	Rp (247,138,500)	Rp (201,915,000)	Rp (156,692,500)	Rp (111,469,500)	Rp (66,246,000)	Rp (21,023,000)	Rp 24,199,000	Rp 69,422,500	Rp 114,645,500	Rp 159,868,000

Table 16: Shrimp product financial projection of 300 ind/m^3 stocking density using low salinity ZWD system to produce 1000 kg shrimp during 70 days culture period.

Years	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Income											
Fresh shrimp		4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
Shrimp price			Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000	Rp 58,000
Total income			Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000	Rp 232,000,000
Expenses											
Feed expenses	Rp 318,230,000										
variable Expences		Rp 151,040,000	Rp 151,040,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000	Rp 176,908,000
Depreciation		Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000	Rp 9,868,000
Total Expenses	Rp 318,230,000	Rp 186,777,000	Rp 160,908,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000	Rp 186,777,000
Profitloss	Rp (318,230,000)	Rp 71,091,500	Rp 45,223,000	Rp 45,223,000	Rp 45,223,000	Rp 45,223,000	Rp 45,223,000	Rp 45,223,000	Rp 45,223,000	Rp 45,223,000	Rp 45,223,000
Net income	Rp (318,230,000)	Rp (247,138,500)	Rp (201,915,000)	Rp (156,692,500)	Rp (111,469,500)	Rp (66,246,000)	Rp (21,023,000)	Rp 24,199,000	Rp 69,422,500	Rp 114,645,500	Rp 159,868,000

Table 17: Shrimp product financial projection of 400 ind/m^3 stocking density using low salinity ZWD system to produce 1000 kg shrimp during 70 days culture period.

Parameter	Treatments		
	SD1 (200 ind./m³)	**SD2 (300 ind./m³)**	**SD3 (400 ind./m³)**
Investment Cost	Rp 443,520,000	Rp 358,080,000	Rp 318,230,000
Revenue	Rp 60,000,000	Rp 60,000,000	Rp 60,000,000
Production Cost/Cycle	Rp 49,087,750	Rp 43,494,625	Rp 44,227,125
Profit/Cycle	Rp 10,912,250	Rp 16,505,375	Rp 15,722,875
Profit/kg Shrimp	Rp 10,912	Rp 16,505	Rp 15,773
BEP (kg)	4,498	2,635	2,804
Net Present Value (NPV)	-175,315,390	47,593,537	69,439,955
B/C Ratio	0.605	1.13	1.22
Pay Back Period (year)	10.16	4.37	4.02
Internal Rate of Return (IRR) (%)	<10	13.40	15.49

Table 18: Financial ratio calculation of ZWD system among different stocking densities to produce 1000 kg shrimps/cycle using low salinity ZWD system.

Acknowledgements

We thank LPPM ITB for the Community Empowerment Research Grant 2014 as the main funding for this study. We also thank Ir. Usman Zuhri as the Head of UD. Popular Nursery, for the kind support in providing shrimp larvae and facilities used in this study.

References

1. FAO (2014) The state of world fisheries and aquaculture: Opportunities and challenges. FAO Publication, Rome.
2. PPEI Indonesia Ministry of Trade (2010) List of 10 Indonesia Main Product.
3. DJPB (2015) Udang Vaname dan Udang Windu Masih Andalan Ekspor.
4. Browdy CL, Bratvold, D, Stokes, AD, McIntosh RP (2001) Perspectives on the application of closed shrimp culture systems. In: Browdy CL, Jory DE (eds.) The New Wave, Proceedings of the special session on sustainable shrimp farming, World Aquaculture Society.
5. Lin YC, Chen JC (2001) Acute toxicity of ammonia on Litopenaeus vannamei Boone juveniles at different salinity levels. J Experit Mar Biol Eco 259: 109-119.
6. Suantika G, Astuti DI, Aditiawati P, Sofyan Y (2009) Pengaruh kepadatan awal inokulum terhadap kualitas kultur Chaetoceros gracilis (Schutt) pada sistem batch. J Math Sci 14: 2.
7. Suantika G, Lumbantoruan G, Muhammad H, Azizah FFN, Aditiawati P (2015) Performance of zero water discharge (ZWD) system with nitrifying bacteria and microalgae Chaetoceros calcitrans components in super intensive white shrimp (Litopenaeus vannamei) culture. J Aquacult Res Dev 6: 359.
8. Budford M, Thompson P, McIntosh, Bauman R, Pearson D (2003) Nutrient and microbial dynamics in high-intensity, zero exchange shrimp ponds in Belize. Aquaculture 219: 393-411.
9. Suantika G, Astuti DI , Aditiawati P, Sasmita PG (2009) Development of zero-water discharge technology and nitrifying bacteria application in nursery phase of the giant freshwater prawn (Macrobrachium rosenbergii de Man). Proceeding World Aquaculture 2009 Mexico.
10. Atlas RM (2004) Handbook of microbiological media 3rd Edition. Washington DC: CRC press
11. Van Wyk P, Davis-Hodgkins M, Laramore R, Main KL, Mountain J, et al. (1999) Farming Marine Shrimp in Recirculating Freshwater System. Florida: Harbor Branch Oceanographic Institution, Florida Department of Agriculture and Consumer Service.
12. Ochoa-Solano JL, Olmos-Soto J (2006) The functional property of Bacillus for shrimp feed. Food Microbiol 23: 519-525.
13. Tacon AGJ, Jory DE, Nunes AJP (2013) Shrimp feed management: issues and perspectives, On-farm feeding and feed management in aquaculture. FAO Fisheries and Aquaculture Technical Rome, Italy.
14. Treece GD, Fox JM (1993) Design Operation and Training Manual for an Intensive Culture System Hatchery. Texas A & M Sea Grant Publication, USA.
15. Eaton AD, Franson MAH (2005) Standard Methods for The Examination of Water and Wastewater. American Public Health Association.
16. Fandeli C (2012) Bisnis konservasi, pendekatan baru dalam pengelolaan sumber daya alam dan lingkungan hidup. Gajah Mada University Press.
17. Suliyanto (2011) Studi Kelayakan Bisnis. Andi, Yogyakarta.
18. Arnold SJ, Sellars MJ, Crocos PJ, Coman GJ (2006) Intensive production of juvenile tiger shrimp Penaeus monodon: An evaluation of stocking density and artificial substrates. Aquaculture 261:890-896.
19. Kautsky N, Ronnback P, Tedengren M, Troell M (2000) Ecosystem perspective on management of disease in shrimp pond farming. Aquaculture 191: 145-161.
20. Wickin JF, Lee DO (2002) Crustacean farming: ranching and culture. In 2ndEdn, Blackwell Science, Oxford, London, Edinburgh, Malden, Carlton, Paris.
21. Moksnes PO, Lipcius RN, Pihl L, van Montfrans J (1997) Cannibal–prey dynamics in young juveniles and postlarvae of the blue crab. J Exp Mar Biol Ecol 215: 157-187.
22. Chavanich S, Viyakarn V, Senanan W, Panutrakul S (2016) Laboratory assessment of feeding-behavior interactions between the introduced Pacific white shrimp Litopenaeus vannamei (Boone, 1931) (Penaeidae) and five native shrimps plus a crab species in Thailand. Aquatic Invasions 11: 67-74.
23. Trubus (2015) Budidaya Vannamei di Air Tawar.
24. DJPB (2012) Budidaya Udang Vannamei Tambak Intensif dengan Plastik Mulsa.
25. FAO (2016) Cultured Aquatic Species Programme Penaus vannamei.
26. Lin YC, Chen JC (2003) Acute toxicity of nitrite on Litopenaeus vannamei Boone juveniles at different salinity levels. Aquaculture 224: 193-201
27. Tsai SJ, Chen JC (2002) Acute toxicity of nitrate on Litopenaeus vannamei Boone juveniles at different salinity levels. Aquaculture 213: 163-170.
28. Katsikogianni M, Missirlis YF (2004) Concise review of mechanisms of bacterial adhesion to biomaterials and of techniques used in estimating bacteria-material interactions. Eur Cell Mater 8:3.
29. Ebeling JM (2006) Biofiltration-Nitrification Design Overview: Recirculating aquaculture system technologies. Aquaculture Systems Technologies, LLC: New Orleans, Los Angeles.
30. Farchan M (2006) Teknik Budidaya Udang Vannamei. Serang: BAPPL-STP.
31. BBAP (2013) Pembenihan Udang Vaname. Situbondo: Seksi Standardisasi dan Informasi BBAP Situbondo.
32. Accuweather (2015) Prakiraan Cuaca Bulanan Gresik.
33. BMKG (2015) Prakiraan Cuaca untuk Jawa Timur.
34. Lubis AD (2009) Kelangkaan Bahan Baku untuk Industri Pengolahan Udang di Jawa Timur. Buletin Ilmiah Litbang Perdagangan 3: 134-152.
35. Indonesia Ministry of Industry (2015) Daftar Perusahaan Pengolahan Udang di Jawa Timur 2015.
36. Agrina-online (2013) Siapkan Amunisi Agar Lokal Makin Terisi.
37. Agrina-online (2015) Mengangkat Produksi Si Bongkok.
38. Rangkuti F (2000) Teknik Membuat Perencanaan Bisnis dan Analisis Kasus. PT Gramedia Pustaka Utama, Jakarta.