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Judul artikel : **Optimizing the utilization of mangrove coastal resources through the application of intercropping ponds/silvofishery in Sinjai Regency, Indonesia**

Jurnal : AACL Bioflux, 2023, Vol. 16, No 1, Hal 474-482

Penulis : Rustam (Koresponden author),

Rustam, Wamnebo M. I., and Hartinah

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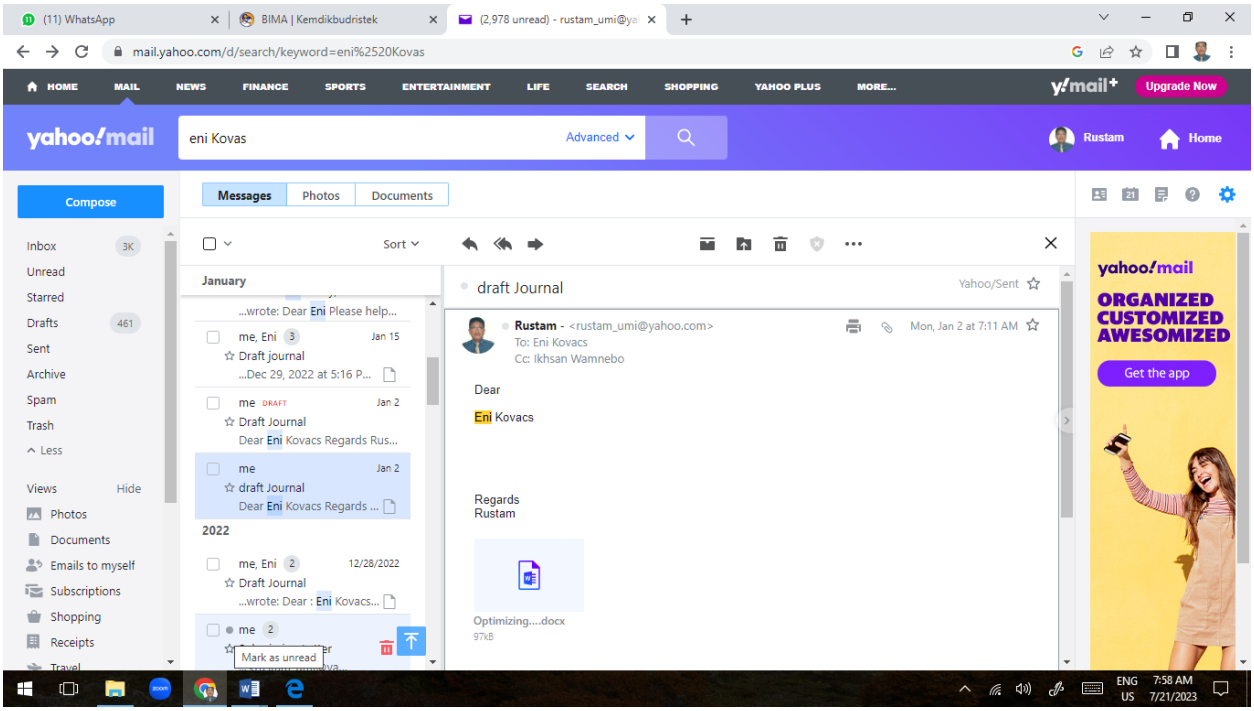

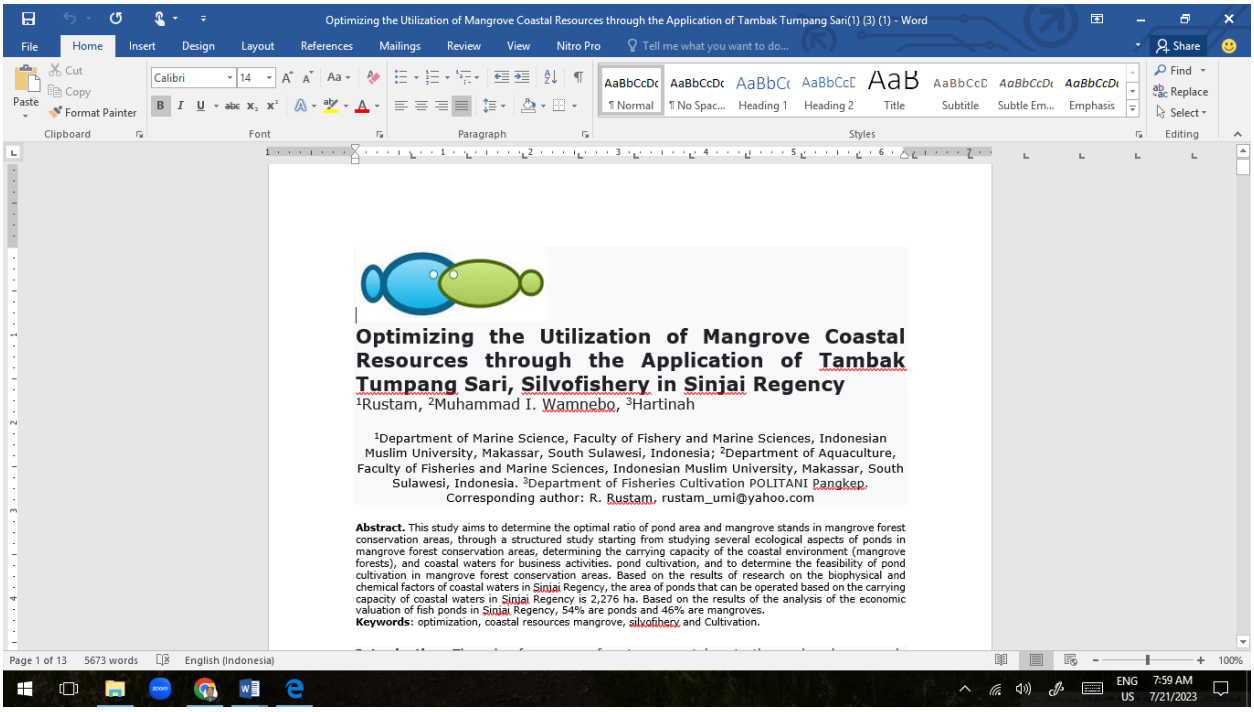

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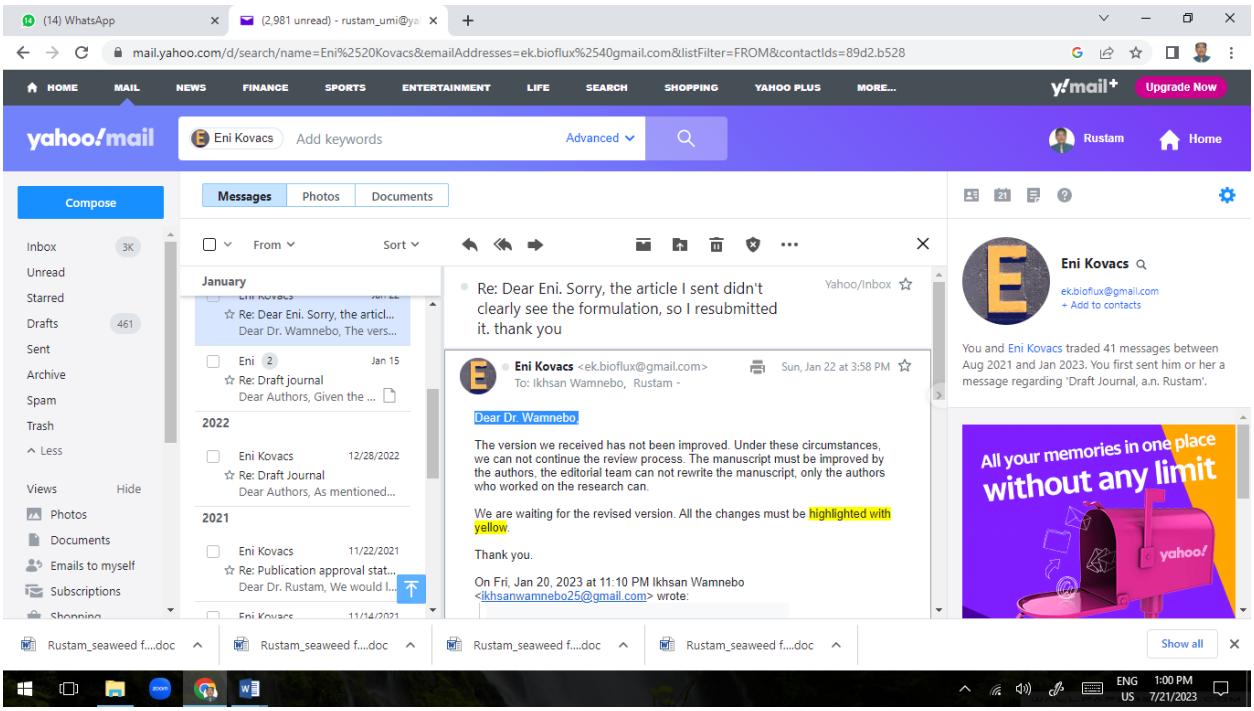

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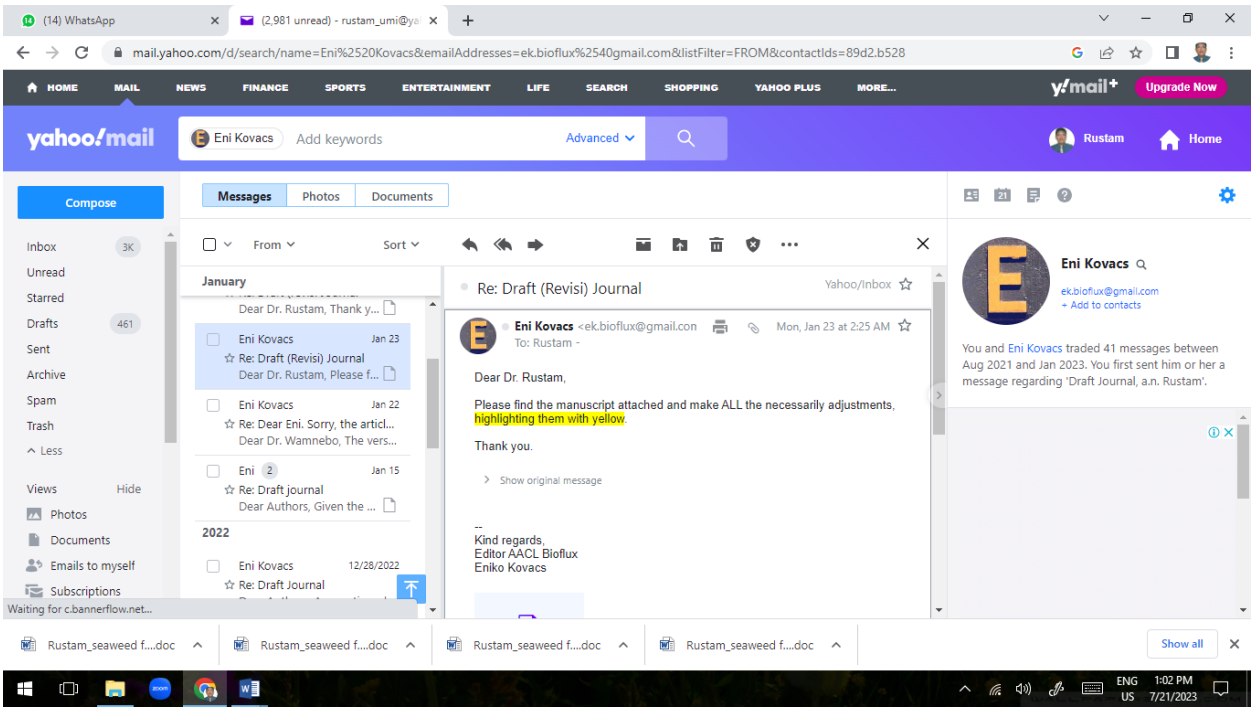

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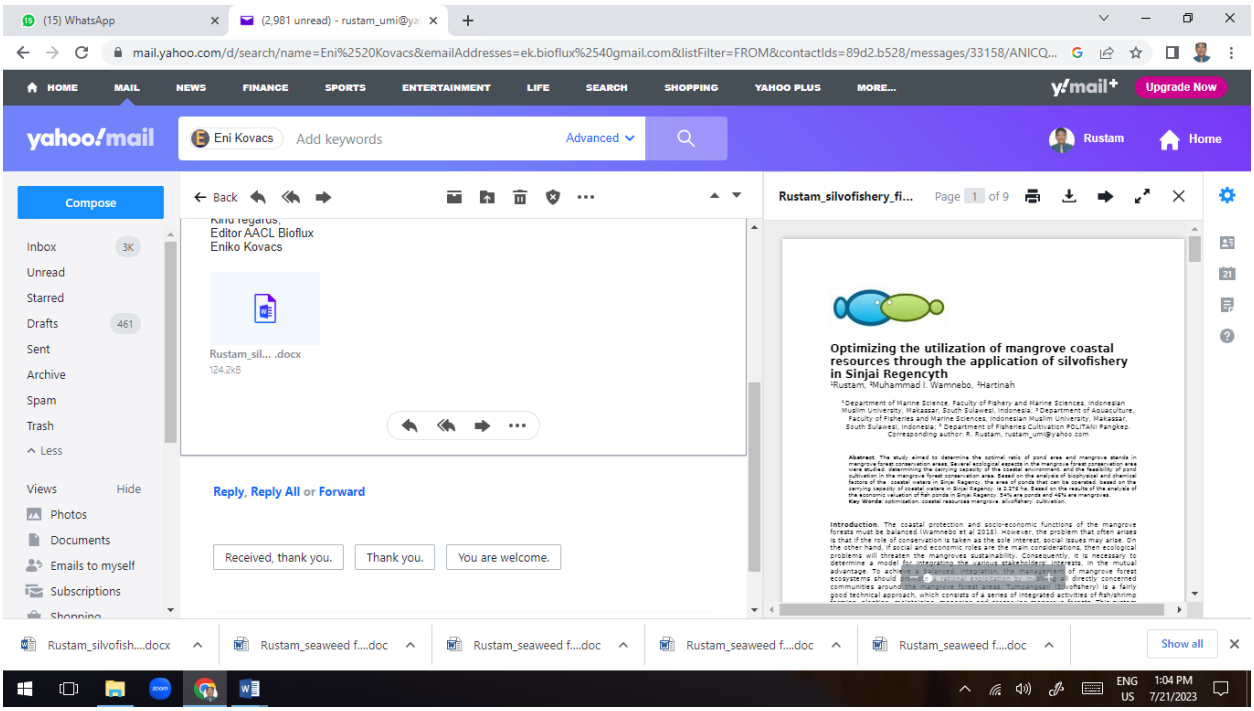
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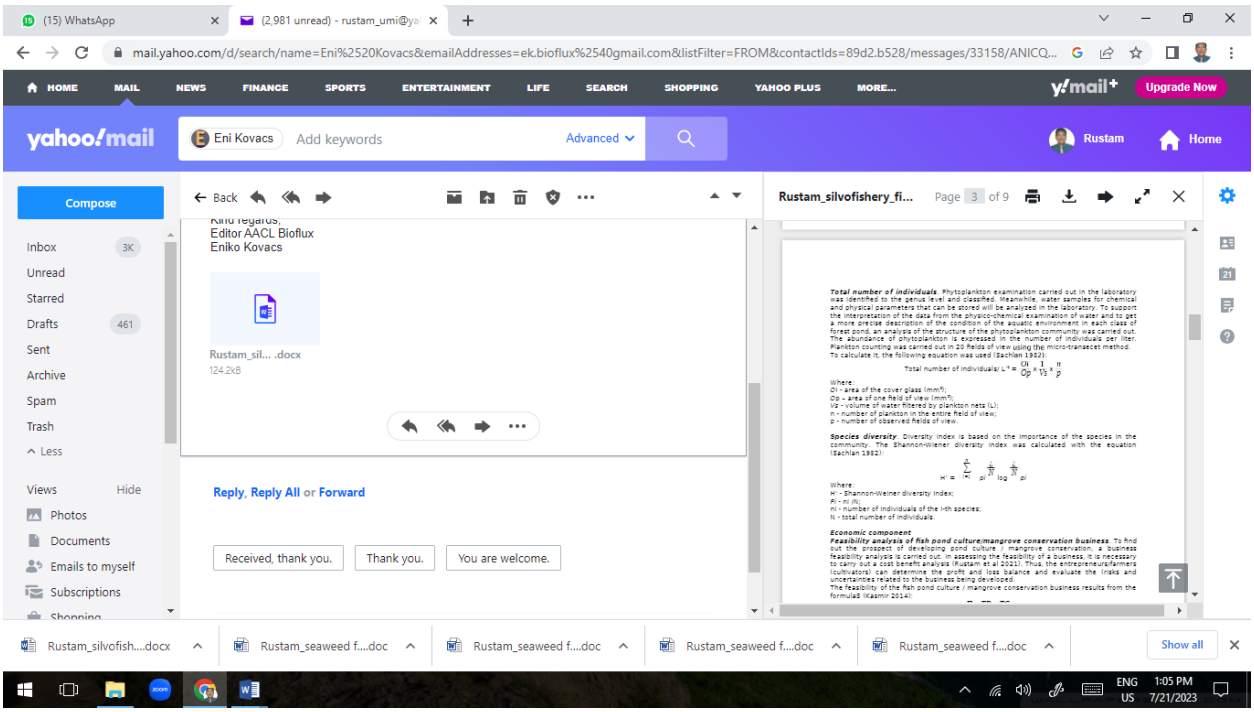
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so that the quality is still feasible for sustainable aquaculture activities. This analysis is based on the assumption of Allison (1981) which states that to maintain the quality of the waters still suitable for aquaculture, the receiving waters of liquid waste from aquaculture activities must have a volume of 100 times the volume of liquid waste discharged into the waters.

Results. Observation results of the biophysical and chemical characteristics of the tides, waves and currents of Coastal Waters in Sinjai Regency are presented in Table 1.

Table 1
Physical condition of coastal waters in Sinjai Regency

Parameters	Values
Tidal hight (h)	126 cm
Range of tides (x)	670 m
Beach width (y)	17 km
Tidal pattern	2 high tides 2 low tides
Beach slope (α)	0.48

Based on the assumptions above, the area of the pond that is feasible to operate for intensive tiger shrimp cultivation in order to remain sustainable is as follows (Table 2).

Table 2
Calculation of sustainable pond area by coastal water volume in Sinjai Regency

Tange n D	Coastal water volume (Vol) (m3)	Tide frequency	Vo available (m³ day-1)	Maximum waste volume in pond (m³)	Pond water volume (m³)	Sustainable area of pond (Ha)
0.107	14.228.288	2	28.456.576	284.506	2.846.058	284.5

The data from the identification of phytoplankton species at different pond and mangrove stations are presented in Table 3 and Figure 1.

Table 3
Composition by species (%) and abundance of phytoplankton (ind L⁻¹) at pond and

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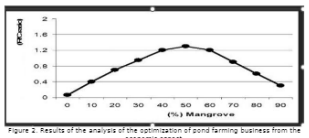

Figure 2. Results of the analysis of the optimization of pond farming business from the economic aspect.

Discussion. Physical conditions of coastal waters Sinjai Regency (Table 1) tidal range 126 cm, tidal range 670 m, 17 km wide beach, tidal pattern 2 times a day, and beach slope of 0.48 degrees. The results of the measurement of aquatic environmental quality parameters that affect the growth and survival of fishshrimp such as temperature, salinity, dissolved oxygen (DO), pH, nitrate and phosphate. These parameters are important to determine the level of suitability of aquaculture land, in general, the range of aquatic environmental parameters measured in the field during the study in the Sinjai Regency is temperature 29-32°C, pH 7.38-7.90, salinity 30-32o/oo, DO 3.62-4.88, NO_3 0.09-0.154. Based on the observation that the water quality is still within the feasible range for marine biota, based on the sea water quality standard for marine biota (fish farming), which is stated in the Decree of the Minister of the Environment No. Kep-02/MNLH/1988, concerning guidelines for setting environmental quality standards (Poernomo 1992; Widigdo 2000, 2001,2002). The dynamic nature of the sea and coast causes the physico-chemical parameters of coastal water to largely range. The movement of water masses results in changes in water quality, the circulation of sea water results in the mixing of water masses and the distribution of nutrients and waste in the waters. In addition, the sea and beaches have a great ability to purify themselves (self-purification), so that everything that happens in seawater can change in a short time (Dahuri 1996, 1998, 1999, 2002). This makes it difficult to assess the quality of sea and coastal waters. However, regardless of the magnitude of the changes, the results of the instantaneous inspection obtained from the chemical oceanographic waters are a real picture of the state of the aquatic environment. This is a reflection of the situation in the longer term.

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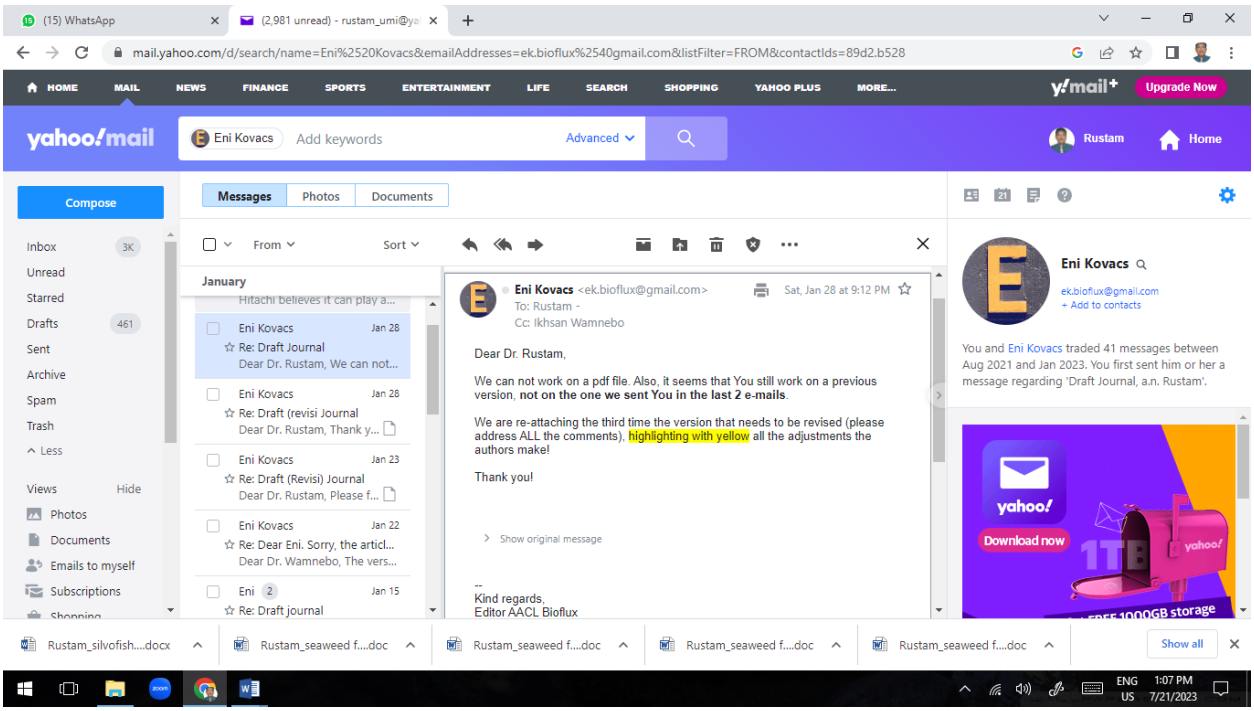

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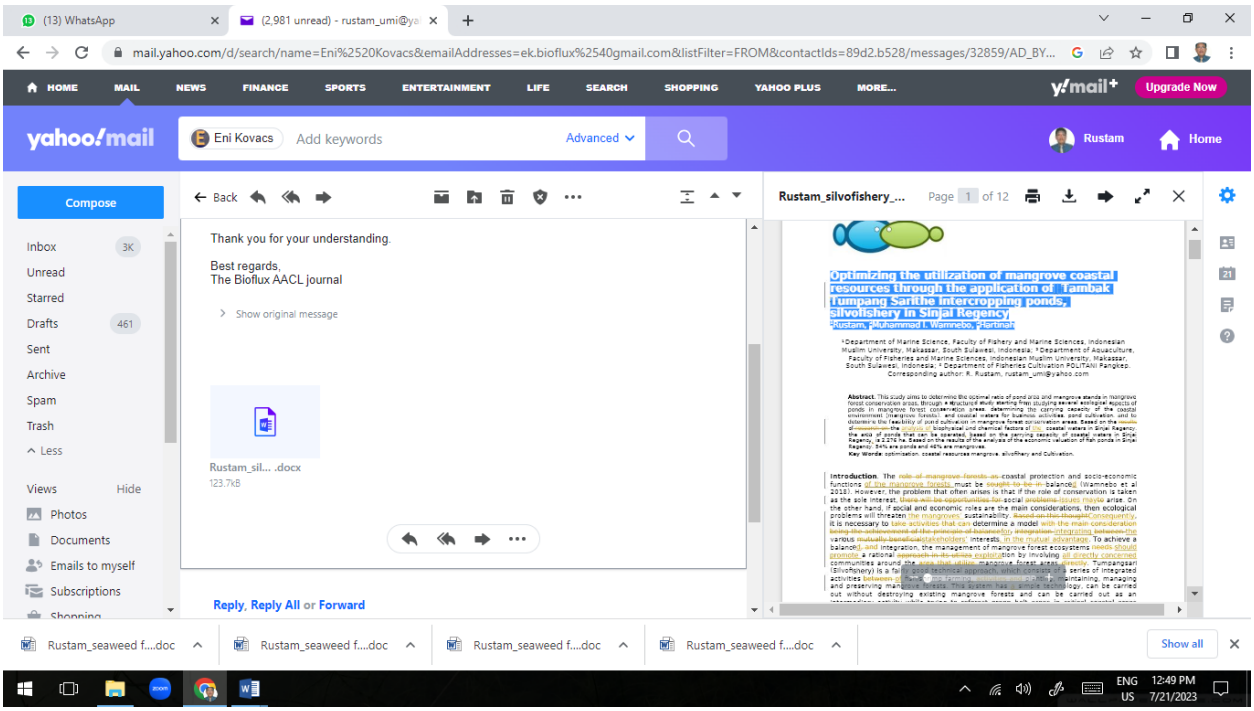
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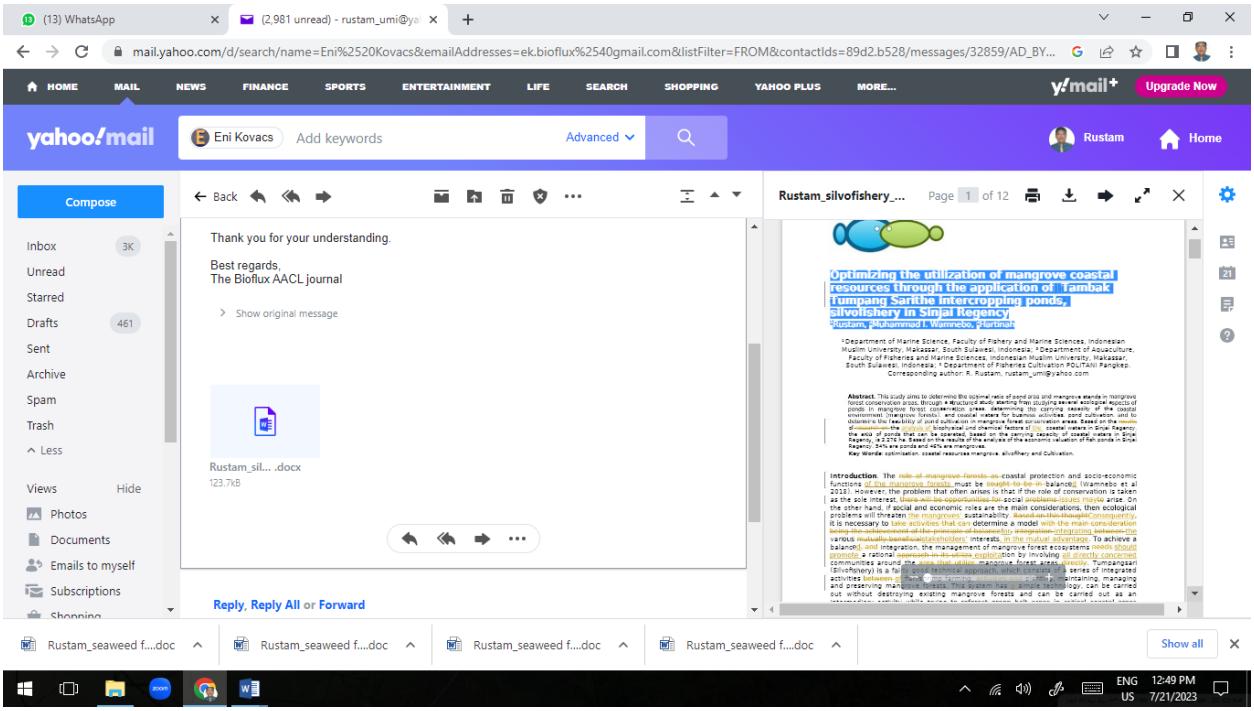
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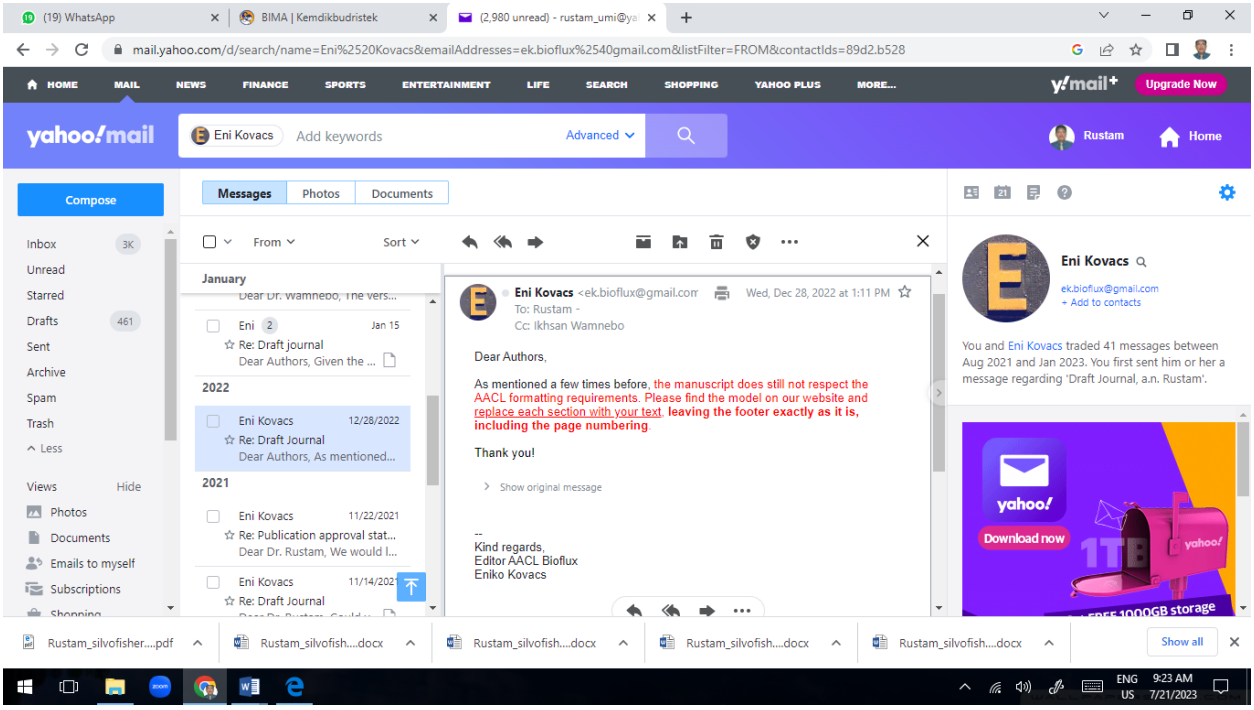

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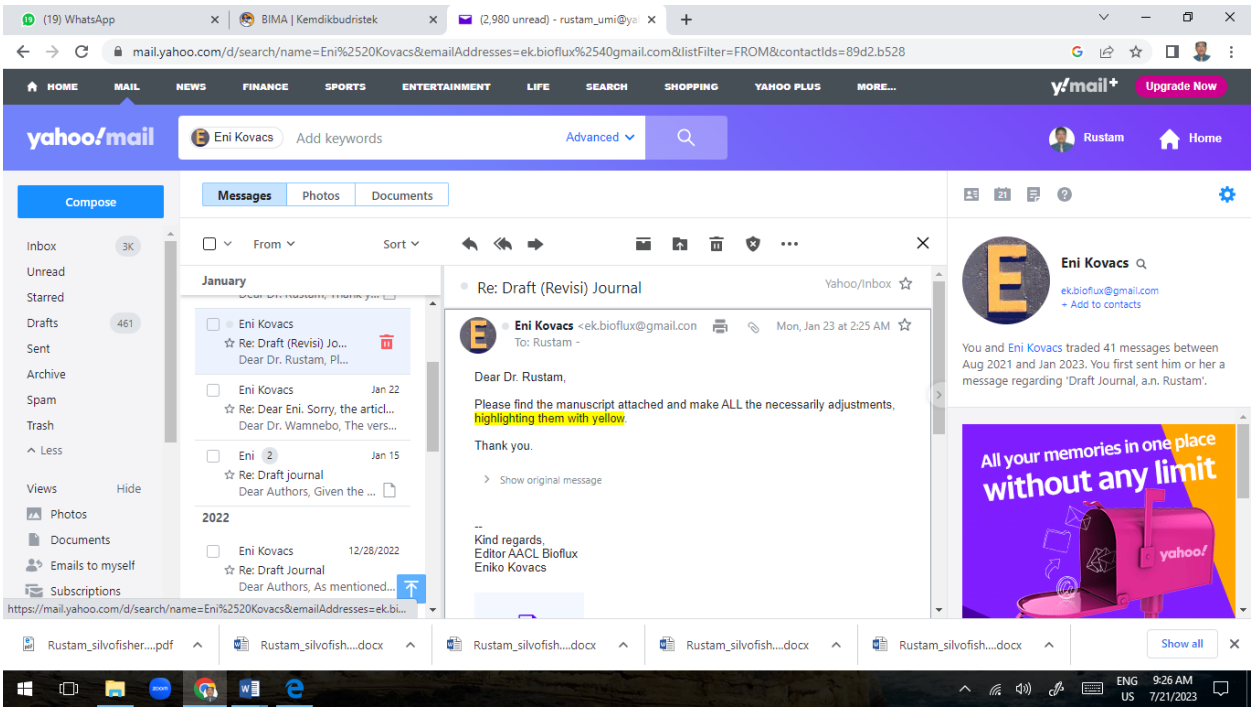

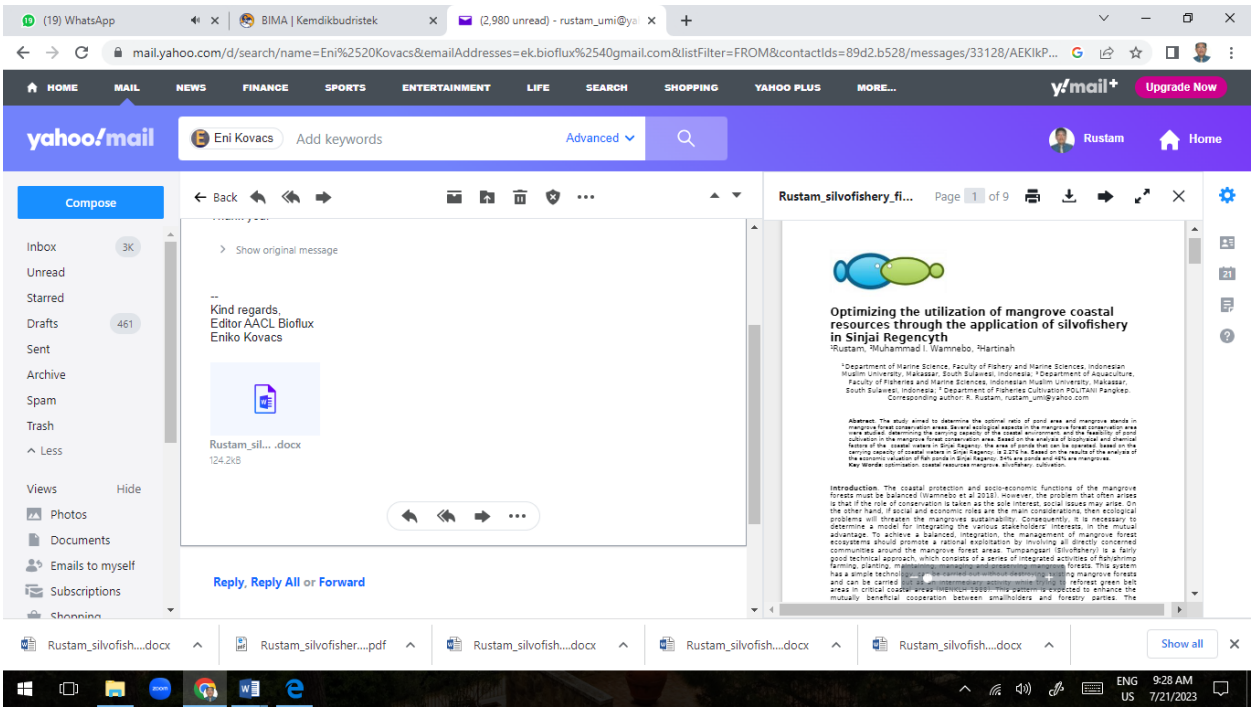

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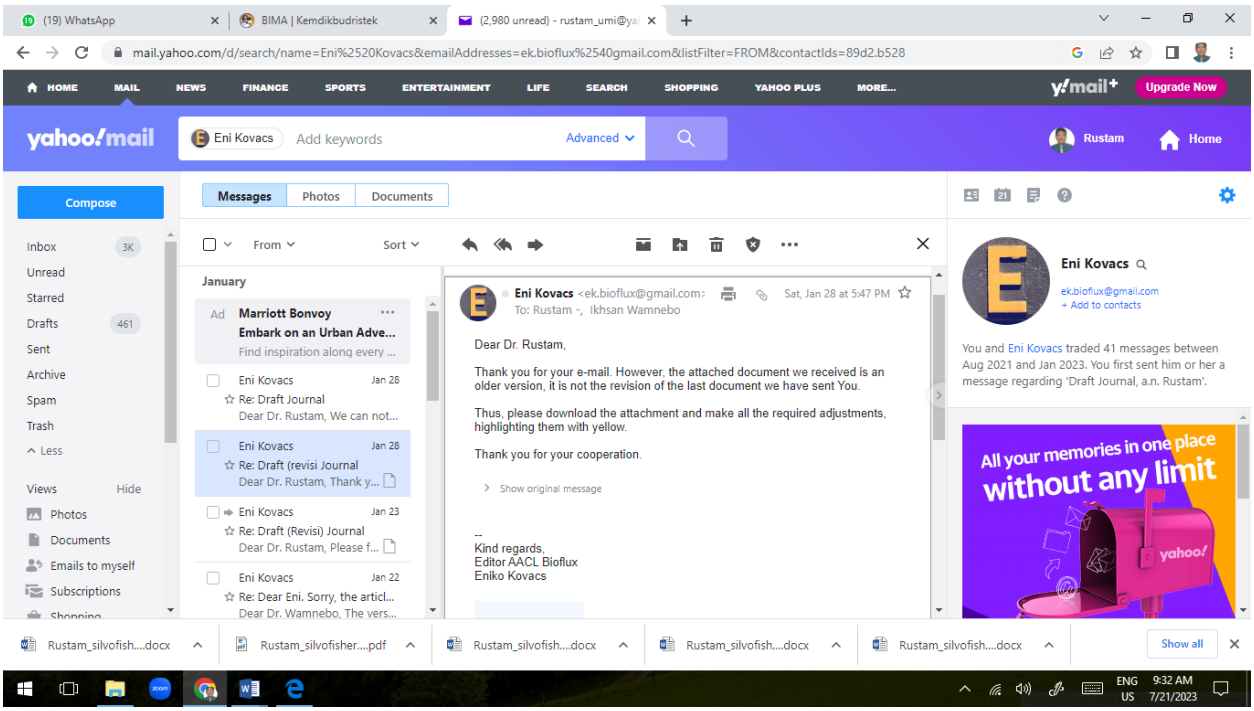
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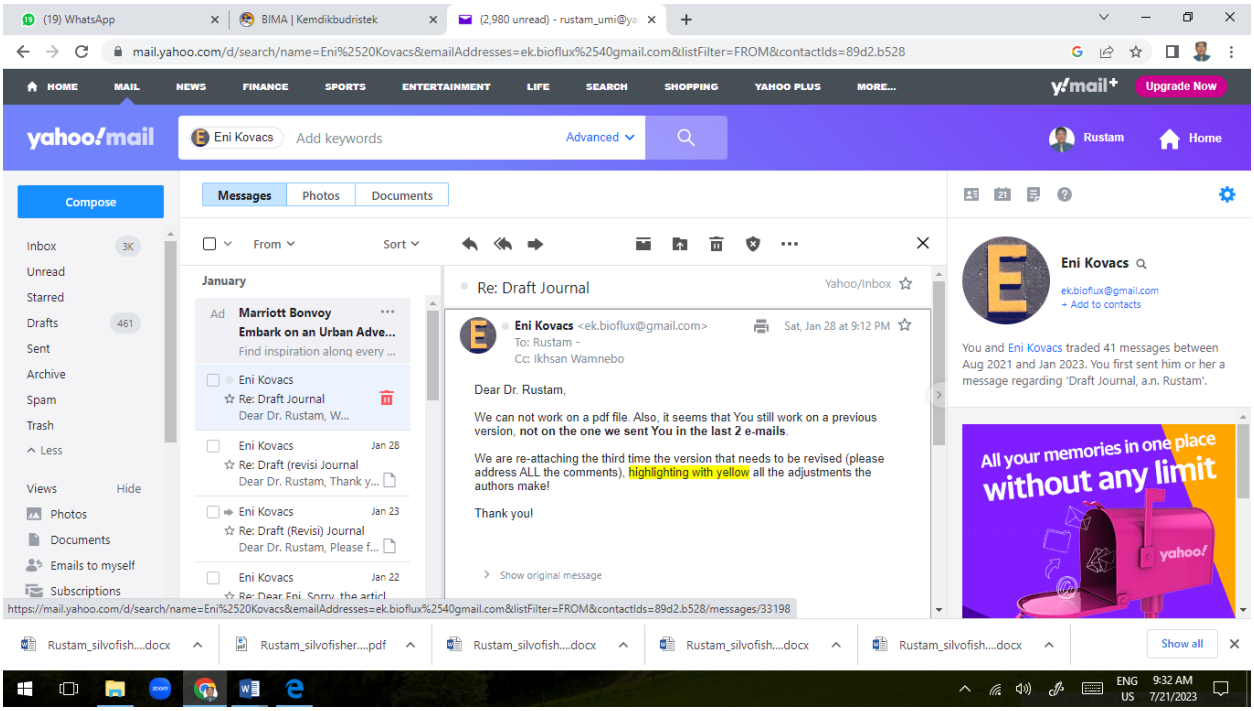
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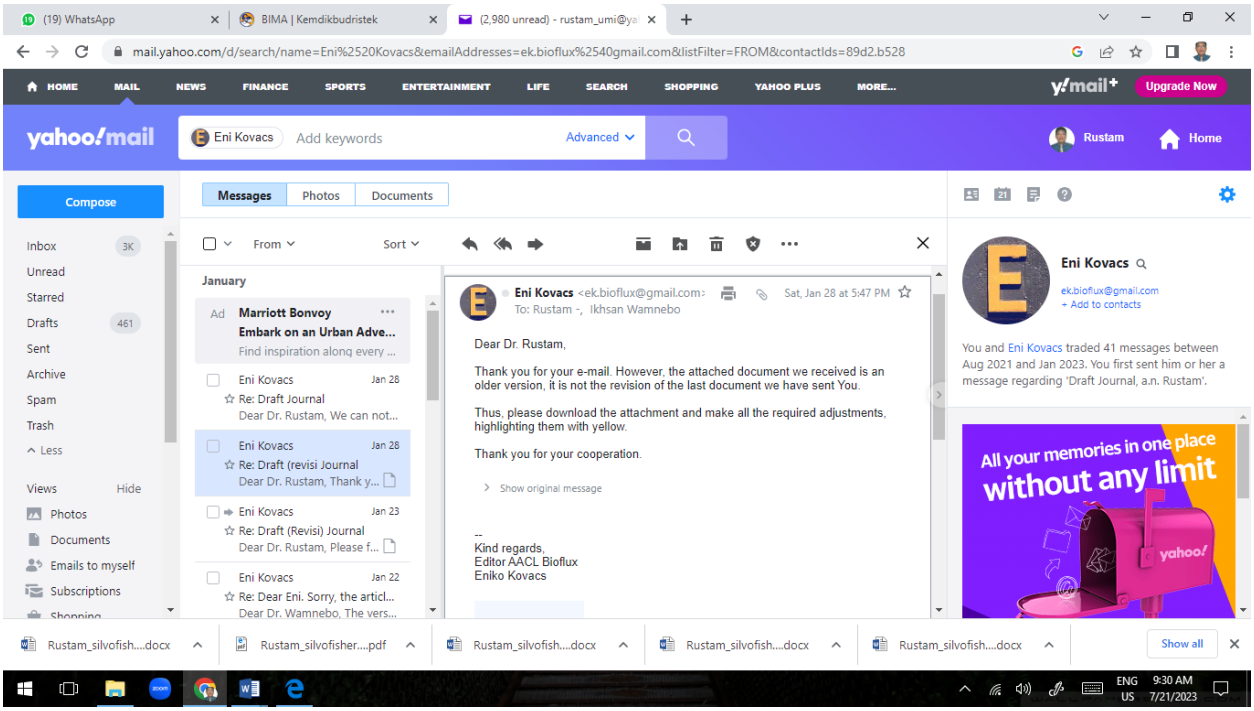
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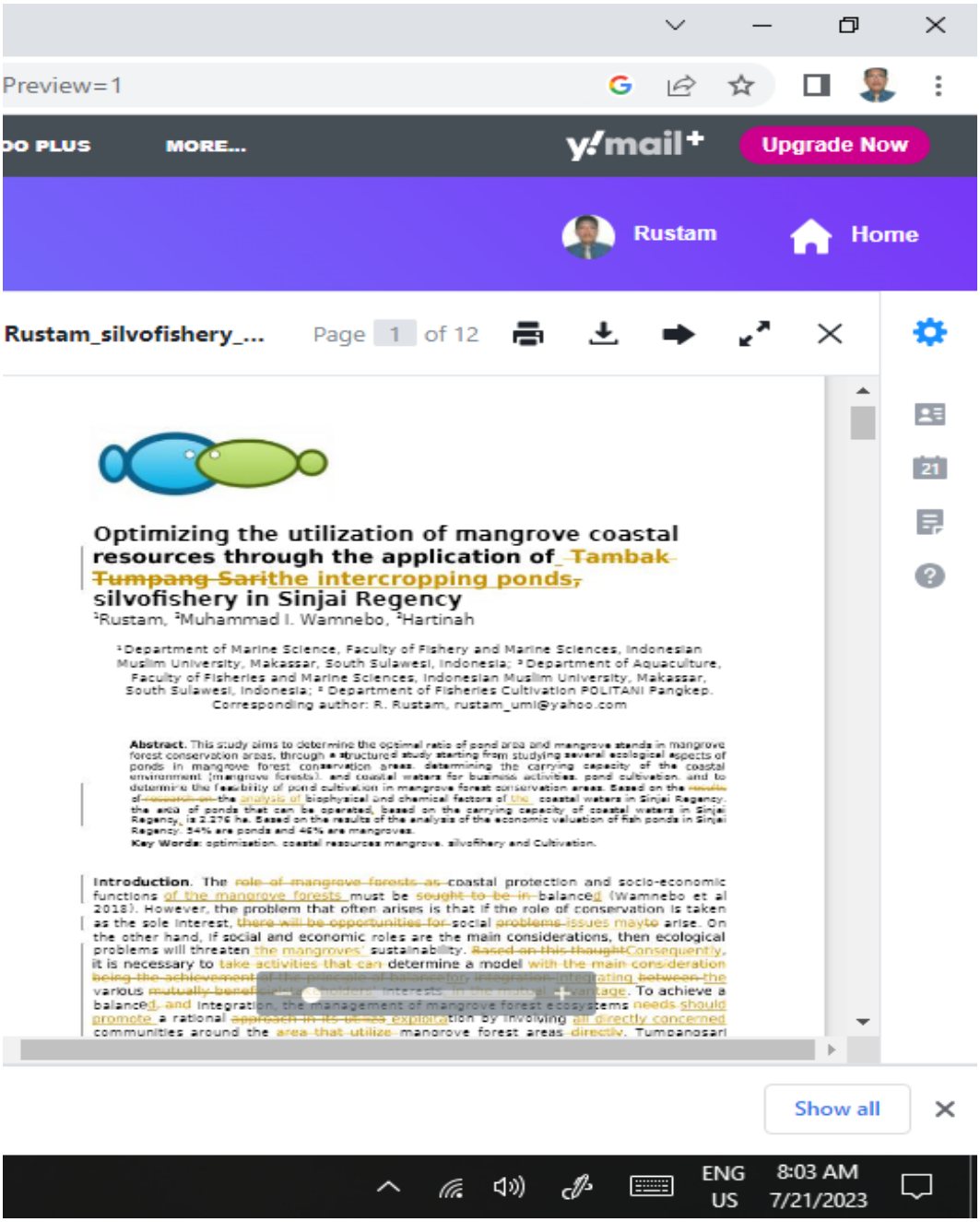

Optimizing the utilization of mangrove coastal resources through the application of the intercropping ponds, silvofishery in Sinjai Regencyth

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Abstract. This study aims to determine the optimal ratio of pond area and mangrove stands in mangrove forest conservation areas, through a structured the study began by studying several ecological aspects in the mangrove forest conservation area, determining the carrying capacity of the coastal environment, and to determine the feasibility of pond cultivation in the mangrove forest conservation area. Based on the analysis of biophysical and chemical factors of the coastal waters in Sinjai Regency, the area of ponds that can be operated, based on the carrying capacity of coastal waters in Sinjai Regency, is 2,276 ha. Based on the results of the analysis of the economic valuation of fish ponds in Sinjai Regency, 54% are ponds and 46% are mangroves.

Key Words: optimization, coastal resources mangrove, silvofishery, cultivation.

Introduction. The coastal protection and socio-economic functions of the mangrove forests must be balanced (Wamnebo et al 2018). However, the problem that often arises is that if the role of conservation is taken as the sole interest, social issues may arise. On the other hand, if social and economic roles are the main considerations, then ecological problems will threaten the mangroves sustainability. Consequently, it is necessary to determine a model for integrating the various stakeholders interests, in the mutual adventage. To achieve a balanced, integration, the management of mangrove forest ecosystems should promote a rational exploitation by involving all directly concerned communities around the mangrove forest areas. Tumpangsari (Silvofishery) is a fairly good technical approach, which consists of a series of integrated activities of fish/shrimp farming, planting, maintaining, managing and preserving mangrove forests. This system has a simple technology, can be carried out without destroying existing mangrove forests and can be carried out as an intermediary activity while trying to reforest green belt areas in critical coastal areas (MENKLH 1988). This pattern is expected to enhance the mutually beneficial cooperation between smallholders and forestry parties. The implementation of silvofishery activities should prevent the destruction of the mangrove forest ecosystem by the local community, because it provides an alternative source of income. There are two main trends in the management of mangrove forests, focusting either on conservation or on utilization functions. These two tendencies will work synergistically if there is a management model that takes into account the appropriate eco-biological and socio-economic principles. The integration between ecology and economy can be harmonized and optimized to meet the needs of today's society without destroying or reducing the ability of these ecosystems, and can provide the needs for future generations. The principle for an optimization of the cultivation technique in ponds located in mangrove forest conservation areas is to seek a combination of ecological and economic integration. order to balance the need for ponds on mangrove land and the maintenance of the ecological function of

mangroves, it is necessary to study the optimal area of ponds to be cultivated on mangrove forest conservation areas. This research aims at determining the optimal area partitioning between pond sand mangrove stands, on the mangrove forest conservation areas, through structured studies examining several ecological aspects, determining the carrying capacity of the coastal environment (mangrove forests and coastal waters) for fish farming activities, and analyzing the feasibility of the pond farming business on mangrove forest conservation lands. Material and Method Litter production. The productivity of mangrove forest was measured as follows: a. The litter was collected using trapping methods b. The sample were put into a cardboard box, then air-dried and weighed. c. The litter samples were put in the oven at 80oC for 48 hours, at the Pangkep State Agricultural Polytechnic Soil Laboratory. Then the litter was weighed again and a constant dry weight was obtained. Mangrove community structure. Data on species, number of stands and tree diameter were further processed to obtain species density, namely the number of stands of spesies on a unit area. calculated by the equation (Sachlan 1982): Di = ni /A Where: Di = density of species i n = total number of stands of species i A = sampling area (plot) Water sampling. Water sampling was carried out during the active phytoplankton photosynthesis process. According to Boyd (1999), the photosynthesis begins to be active in the morning and increases until noon, then decreases towards the afternoon. On this basis, water samples were taken during the day (11.00-13.00). Observations were carried out in the pond forest areas stocked with milkfish or/and shrimp. Phytoplankton were taken from four places, namely water in the pond (two points) in the corner and two other points in the center of the pond. For each sampling point, 5 liters of water were taken, so that from one sampling location there were 20 liters of sampled water, which were poured into plankton net bag(number 25). Portions of filtered water were accommodated in a 10 ml glass and 5-6 drops of preservative were added, then the sample was put in a closed bottle and analyzed in the Water Quality Laboratory of the Pangkep State Agricultural Polytechnic. Water samples for analysis of physical and chemical parameters were taken together with water samples for composite phytoplankton examination. Approach/analysis model Ecological component Litter production The mean (average) litter production for each observed plot was determined by the formula (Sachlan 1982): average litter production per plot in a certain time period; Xi - litter production for the ith (i = 1,2,3,….n) plot in a certain time period (g m-2 month-1) n - Number of litter traps The average value of litter production for each forest pond and for each observation is determined by the formula (Sachlan 1982), Where: X - average litter production per forest pond for a certain time Xj - average litter production per plot, for the period (g m-2 month-1) M - number of sample units per pond forest. Phytoplankton community structure index Total number of individuals. Phytoplankton examination carried out in the laboratory was identified to the genus level and classified. Meanwhile, water samples for chemical and physical parameters that can be stored will be analyzed in the laboratory. To support the interpretation of the data from the physico-chemical examination of water and to get a more precise description of the condition of the aquatic environment in each class of forest pond, an analysis of the structure of the phytoplankton community was carried out. The abundance of phytoplankton is expressed in the number of individuals per liter. Plankton counting was carried out in 20 fields of view using the micro-transecet method. To calculate it, the following equation was used (Sachlan 1982): Total number of individuals/per liter = □□□□ x□□□ x □□ Where: Oi - area of the cover glass (mm2); Op – area of one field of view (mm2); Vs - volume of water filtered by plankton nets (L); n - number of plankton in the entire field of view; p - number of observed fields of view. Species diversity. Diversity index is based on the importance of the species in the community. The Shannon-Wiener diversity index was calculated with the equation (Sachlan 1982): H’ = □□ni 1pi □□□ log □□□ pi Where: H' - Shannon-Weiner diversity

index; Pi - ni /N; ni - number of individuals of the i-th species; N - total number of individuals. Economic component Feasibility analysis of fish pond culture/mangrove conservation business. To find out the prospect of developing ponds/ponds aquaculture, a business feasibility analysis is carried out. In assessing the feasibility of a business, it is necessary to carry out a cost benefit analysis (Rustam et al 2021). Thus, the entrepreneurs/farmers (cultivators) can determine the profit and loss balance and evaluate the (risks and uncertainties related to the business being developed. The feasibility of the fish pond culture / mangrove conservation business results from the formulas (Kasmir 2014): Π = TR – TC and R/C ratio = TR / TC Where: Π – profit; TR - total revenue in a certain period; TC- total cost used in one production cycle.

If the R/C ratio > 1, then the business can be profitable If the R/C ratio < 1, then the business is losing If the R/C ratio = 1, then the business is neither profitable nor losing. Optimization of land use. Analysis of the land use optimization is carried out based on economic aspects. The economic aspects that are taken into consideration are the value of the R/C ratio. Economic analysis is looking for the optimal partition of the land area between the pond and the mangrove forest, in the intercropping pond (silvofishery). Analysis of the carrying capacity of coastal waters. The analysis of the carrying capacity of these waters is based on the limits of the waters as waste recipients. The quantity of receiving water is a determinant of how much waste a water body can receive so that the quality is still feasible for sustainable aquaculture activities. This analysis is based on the assumption of Allison (1981) which states that to maintain the quality of the waters still suitable for aquaculture, the receiving waters of liquid waste from aquaculture activities must have a volume of 100 times the volume of liquid waste discharged into the waters. Results. Observation results of the biophysical and chemical characteristics of the tides, waves and currents of Coastal Waters in Sinjai Regency are presented in Table 1. Table 1 Physical condition of coastal waters in Sinjai Regency Parameters Values Tidal hight (h) 126 cm Range of tides (x) 670 m Beach width (y) 17 km Tidal pattern 2 high tides 2 low tides Beach slope (□) 0.45 Based on the assumptions above, the area of the pond that is feasible to operate for intensive tiger shrimp cultivation in order to remain sustainable is as follows (Table 2). Table 2 Calculation of sustainable pond area by coastal water volume in Sinjai Regency Tangen 0 Coastal water volume (Vo) (m3) Tide frequency Vo available (m3 day-1) Maximum waste volume in pond (m3) Pond water volume (m3) Sustaniable area of pond (Ha) 0.107 14.225.289 2 28.450.578 284.506 2.845.057 284,5 The data from the identification of phytoplankton species at different pond and mangrove stations are presented in Table 3 and Figure 1.

plankton. Phytoplankton are microscopic plant organisms that live floating in water and are primary organisms in the food chain. Phytoplankton is one of the biological parameters to determine the level of water fertility (Odum 1971). Figure 1 and Table 3 above shows that at the mangrove forest station Bacyllariophycea is the dominant type of phytoplankton (78.82%), then Chlorophycea with a composition of 11.49%, Cyanophyceae with a composition of 5.08%, Dyanophycea and Euglenophycea each at 3.74.% and 0.87%. Several species of Bacyllariophycea (diatoms) such as Chaetoceros, Nitschia, Cosconodicus and Rhizosolenia are species that have a fairly high frequency of occurrence and abundance. Chaetoceros and Nitschia are types of diatoms favored by fish and shrimp. The types of Chlorophyceae that appear frequently are Coelastrum, Oocystis, Oodegenium, Ulothrix and Microsphora. The types of Cyanophyceae obtained were Calothrix, Oscillatoria, Trichodesmium and Spirulina. From the class Dynophyceae, the types that are often obtained are Ceratium and Noctiluca. While the Euglophyceae class, the types obtained are Euglena. Based on the results of phytoplankton identification, it is known that there are at least 5 classes of phytoplankton found in Sinjai Regency, namely Bacillariophycea, Chlorophycea, Cyanophycea, Phyopphyceae and Euglenophycea. The data

from the identification of phytoplankton species in pattern I 100% ponds and Patterns II, III and IV silvofishery (intercropping) each with pattern I 25% mangrove: 75% pond, Pattern II 50% mangrove 50% pond and Pattern III 75% mangrove : 25% different ponds as presented in Table 4. Meanwhile, the composition of species and abundance of phytoplankton in Sinjai Regency for each pattern is presented as follows. The lowest diversity value was found in Pattern IV 75% mangrove: 25% ponds and the highest in pattern I 100% ponds. According to Odum (1971) that the value of diversity 1-3 is included in the moderate level of diversity, while the classification According to Lee et al (1978) that the uniformity index is between 1.0 - 2.0 lightly polluted and > 2.0 is not polluted. Based on the uniformity index, the observation area in Sinjai Regency is included in the moderate level of diversity with the category of unpolluted and lightly polluted areas. Meanwhile, the value of the species uniformity index (I) from all observation stations obtained a value in the range of 0.592 - 0.651. According to Odum (1971), the uniformity index is between 0.5 – 1.0, so the distribution of individuals between species is relatively even. Based on this, the condition of phytoplankton at each station in the aquaculture and silvofishery forest areas showed an even distribution of individuals. In addition to the abundance of phytoplankton, according to Hartinah and Rustam (2018) that several mangrove species (R. apiculata, B. gymnorhyza) (A. alba, N. fruticans) have antimicrobial effects against Vibrio bacteria (Effendi 1998). Vibriosis disease is caused by the Gram negative Vibrio bacteria, namely; V. parahaemolyticus, V. alginolyticus, and V. Anguillaru, are one of the causes of the increased carrying capacity of mangrove waters for shrimp culture in the sylvofishery system. Carrying Capacity of Coastal Areas for Fish/Shrimp Cultivation Activities Based on Availability of Water Volume. The volume of water available on the coast is calculated using an approach like that of Widigdo et al (2001) based on the length of the coastline, the range of tides, the slope of the bottom of the waters and the distance from the shoreline at high tide towards the sea until it reaches the point where the water depth at the lowest low tide is one meter equal to the depth of the seawater intake pipe for ponds. Based on the calculated data in the waters of Sinjai Beach (Table 2), the volume of water available on the beach (Vo) is obtained 14,225,289 m3 and the volume available per day is 28,450,578 (2 tides). The carrying capacity of coastal waters as waste recipients is a determining factor for how much waste will be accepted so that the quality is still suitable for shrimp/fish farming activities. In connection with this, the determination of the carrying capacity of coastal waters for shrimp aquaculture activities can be determined using the approach of several expert opinions in aquaculture and environmental experts which can be used as a basis for reference. Alison (1981) stated that in order to maintain the quality of public waters that are still suitable for aquaculture, waters receiving liquid waste from

 aquaculture activities must have a volume between 60-100 times the volume of liquid waste discharged into public waters. Boyd (1998; 1999) stated that the maximum feed capacity for 1 ha of intensively managed ponds is 100-150 kg/day. Moreover, the water will no longer be able to maintain its quality. In shrimp farming in ponds, the maximum feed is given when the shrimp is approaching harvest weighing between 30-35 grams/head. At this size, the dose of feed given is 2.2-2.5% per day. This condition is intended for intensive shrimp farming with a weight (biomass) of about 4 tons/ha (Widigdo 2002). The average daily water discharge is 10% of the total pond water volume. Based on this value, it was found that in Sinjai Regency, it was found that the optimum area of ponds could be operated by intensive cultivation of 284.5 ha with a production capacity of 3.5 – 4.0 tons/ha. Semi-intensive shrimp farming is 569 ha with a production target of 1.5 – 2.0 tons/ha/MT, traditional shrimp farming with a production target of 500

kg/ha/MT, the area of the pond that can be operated is only 2276 ha. Mangrove ecosystem in Sinjai Kabupaten Regency. Mangrove ecosystem is a coastal ecosystem composed of various types of vegetation that have specific biological and physiological adaptations to environmental conditions that are quite varied. The mangrove ecosystem is generally dominated by several true mangrove species including Rhizophora sp, Aveicenia sp, Bruguiera sp and Sonneratio sp. These mangrove species can grow well in shallow water ecosystems, because of the form of roots that can help to adapt to the aquatic environment, both from the influence of tides and other factors. Other environmental factors that influence such as temperature, salinity, dissolved oxygen, sediment, pH, currents and waves. Mangrove type and density composition. In general, the types of plants that make up the mangrove ecosystem at the research site consist of true mangrove species and associated mangroves. The true mangrove species in question include: mangrove species Rhizophora sp, Avicenia sp, Bruguiera sp, Sonnerati sp, Ceriops sp, Fruticans sp and Acanthus ilicifolius. Meanwhile, the associated mangrove species consisted of Ipomoea pes-caprae. The distribution of each Sinjai mangrove vegetation is mangrove Rhizophora sp, Avicenia sp, Bruguiera sp, Sonneratio sp. The condition of the mangrove forest on the coast of East Sinjai in 1985 was in a damaged state, and the east coast was open. At that time, strong and open winds hit the fishermen's settlements on the coast. The condition of the muddy beach reaches a depth of 0.5 – 1 m, this condition arises in the community's thinking to carry out the planting of Rhizophora mangroves independently. The condition of mangrove forests in the East Sinjai area in Tongke-Tongke and Samataring villages is quite good. This is supported by the local governments policy which issued a Regional Regulation on Mangrove Forests in 1999. Economic valuation of ponds. Based on the economic valuation of ditch ponds in Sinjai Regency (Tabel 5) with various patterns applied, namely by assessing the Total Revenue (TR) and Total Cost (TC), R/C ratio of ponds/pond ditches (silfovishery) in various patterns in Sinjai Regency. The value of the R/C ratio in the ponds pattern 1 to IV varies between 1.1 – 1.57. In general, the economic valuation of each pond pond pattern is more than 1.0. This means that the embankment ditch pond business is feasible. Based on the analysis of variance, the R/C ratio showed a significantly different value from the regression analysis (Figure 2) with the equation Y = 0.598 + 0.030X - 0.00027 X2. The maximum value of the R/C ratio produced is 1.40, which is 54% or the composition of 54% water and 46% mangrove forest. To find out the results of the analysis of variance and further tests can be seen in the appendix. Based on the results of polynomial analysis of the economic aspect, the optimum R/C ratio value is 1.40 with a pond area of 54%. Based on this analysis, the optimization from the economic aspect is 54% embankment ditch ponds and 46% mangrove forests. Conclusions. Based on the bio-physical and chemical factors of the coastal waters of Sinjai, the area of the pond that can be operated based on the maximum environmental carrying capacity of the coastal waters in Sinjai Regency is a maximum of 2,276 ha. Based on the results of the economic valuation analysis for ponds/ponds in the Sinjai area, the