Factor affecting the willingness to adopt good aquaculture practices (GAPs) in traditional shrimp farming in Pinrang Regency, South Sulawesi Province, Indonesia

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Abstract. This study explores the factors influencing shrimp farmers' adoption of Good Aquaculture Practices (GAPs) in traditionally managed aquaculture ponds cluster in Pinrang Regency, South Sulawesi Province, Indonesia. The factors influencing shrimp farmers' decision to apply GAPs to traditional ponds in Pinrang Regency were analyzed using the Theory of Planned Behavior (TPB) with structural equation modeling (SEM). The analysis results showed that shrimp farmers' willingness to adopt GAPs was strongly influenced by their attitude that GAPs can increase their production or income, improve a positive reputation in society, and contribute to improving the aquaculture environment. Meanwhile, the main impetus for adopting GAPs came from exporters or local entrepreneurs and directives and assistance from the relevant government, universities, and academics. The shrimp farmers believe that to maximize the level of application and the adoption of GAPs, improving pond engineering and managing environmental limiting factors are of high priority. The decline in aquaculture pond water quality is closely related to the condition of ponds with problems exchanging water, particularly disposing of aquaculture waste after the operation.

1 Introduction

Various aquaculture management and policies have been disseminated to support the sustainability of brackish water aquaculture activities worldwide [1]. The Network of Aquaculture Centers in Asia-Pacific (NACA) in 2011, for example, introduced the concept of "Better Management Practices" (BMPs) to help reduce the risk of disease attacks, particularly pathogenic diseases caused mainly by viruses (e.g., hematopoietic necrosis virus-IHHNV, yellow head virus-YHV, Taura syndrome virus-TSV, white spot syndrome virus-

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WSSV and infectious myonecrosis virus-IMNV) and anticipate other environmental problems [1,2]. The BMPs are also known as Good Aquaculture Practices (GAPs). In Indonesia, the GAPs principles are adapted according to local land characteristics and management models. The GAPs concept has been established by MMAF regulation number 02/Permen KP/2007 and GAPs technical guidelines by the Director General of Aquaculture (DGA) regulation Number 65/PER-DJPB/2015 [3,4]. The DGA's regulation on GAPs' technical guidelines covers the process from identifying risk factors to developing risk management practices. In 2012, the concept of GAPs in Indonesia was synergized with the FAO guidelines and the ASEAN Shrimp GAPs Standard to guarantee a national quality system to be dynamically competitive in regional, national, and international markets. Regarding shrimp farming, GAPs comprise four basic principles of technical aspects: technical, management, food safety, and environmental [3]. The primary goal of GAPs is to increase production and promote responsible and sustainable aquaculture practices. Therefore, adopting GAPs aims to improve production practices, reduce disease risks, increase yields, and contribute to sustainability and economic viability

The same study by [5] in Pesawaran District showed that the GAPs program and certification in shrimp farming activities have been running since 2017, but its implementation needs to be carried out properly following the standard GAPs guidelines. Problems in implementing GAPs included the need for more awareness and commitment of aquaculture actors to the importance of applying the GAPs concept. Although GAPs schemes may improve shrimp farm profitability, various obstacles may restrain farmers from adopting them [6,7,8]. The significant challenges in implementing GAPs schemes included the necessary to provide additional costs and workforce to help manage water supply to ponds; pond preparation; maintenance pond design, facilities and equipment; stocking; management of fish fry, fish feed, and supply of other inputs [2,7,9]. All these factors drive farmers' behavior and potentially reduce their willingness to adopt GAPs.

Technology or innovation is only useful once targeted users adopt it. To buy a product or adopt a new technology, individuals do not decide spontaneously but go through several decision-making stages. Adoption, by definition, is a process of changing behavior in the form of knowledge (cognitive), attitude (affective), and skills (psychomotor) in a person after receiving a message conveyed by extension agents to their targets [10,11]. Past studies suggested that the Theory of Planned Behavior (TPB) can assess behavioral intentions determinants that lead individuals to adopt a given decision [12]. Using TPB, the person's intention or willingness can forecast the likelihood of a specific behavior; thus, effective frameworks for behavior change can also be provided [12, 13]. For example, several TPB studies have been successfully developed in agriculture to predict farmers' behaviors and decisions in adopting environmental and sustainability-based agriculture policies. [14] utilized an analytical method to determine farmers' motivation in adopting the concept of sustainable agriculture. While the promotion, implementation, and adoption of GAPs have been widely studied in the literature [2,5,6,7,15,16], the determinants of farmers' behavior or decisions to adopt GAP programs have been less studied.

This study explores factors affecting the adoption and implementation of GAPs through an analysis of individual interviews with traditional shrimp farmers. Using structural equational modeling (SEM), the following hypothesizes were tested:

H1: The attitude of the shrimp farmers has a significant impact on their willingness to adopt GAPs schemes

H2: Subjective norms of the shrimp farmers have a significant effect on their willingness to adopt GAPs schemes

H3: Perceived behavioral control of the shrimp farmers has a significant impact on their willingness to adopt GAPs schemes.

2 Data and methods

2.1 The study area

This study was conducted at traditional shrimp pond clusters (also known as extensive shrimp pond clusters) in Lanrisang District and Mattirosompe District, Pinrang Regency, South Sulawesi Province, Indonesia (Fig. 1). The pond clusters were selected for research locations using monographic data from local fisheries extension officers and information on implementing GAPs from relevant agencies.

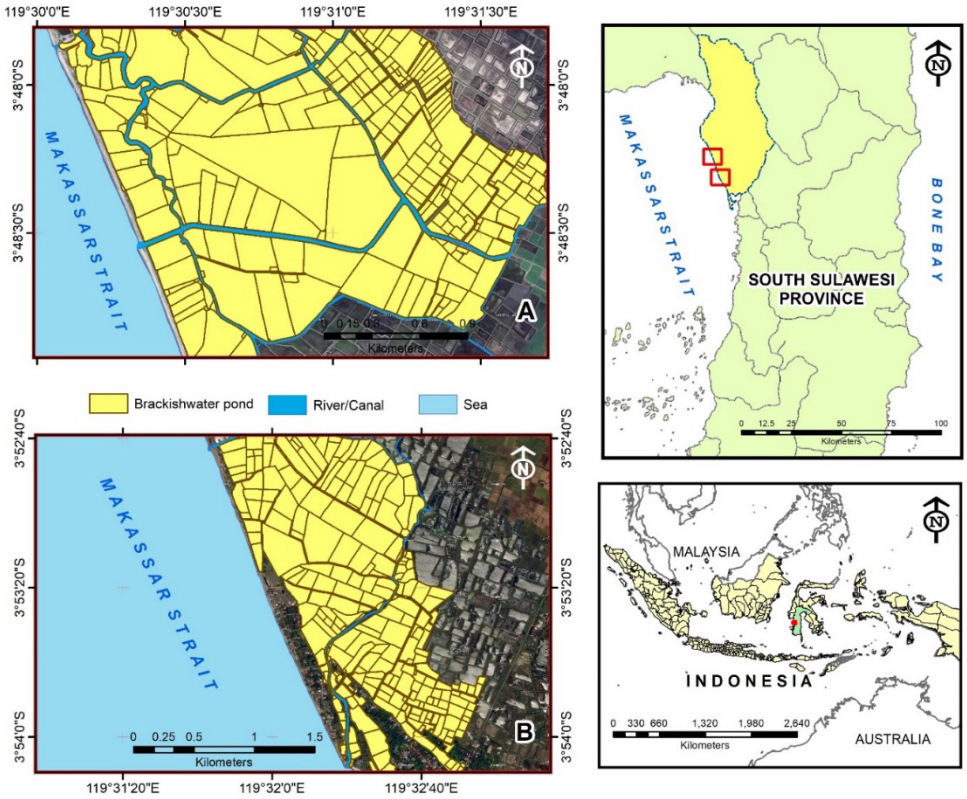

Fig. 1. Map of study sites in Pinrang Regency, South Sulawesi Province (A = Mattirosompe; B= Lanrisang).

2.2 Data collection and analysis

Primary data were collected through interviews with traditional shrimp farmers and served as the primary source of information. Field observation was also conducted to verify the interview results and better understand existing environmental and production limiting factors. The data collection process employed a purposive sample technique, whereby respondents were deliberately selected based on their prior engagement in Good Agricultural Practices (GAPs) applicable to traditional brackish water aquaculture. A total of 116 out of 334 traditional shrimp farmers were selected for participation in an interview. Most of these farmers were classified as smallholders, with almost 70% reporting that their farms covered an area of two hectares or less. The majority of respondents were between the ages of 20 and 60, with the average age of participation falling between 30 and 50. Before the interview,

participants were provided with an explanation of the study's objectives and the instructions to fulfill the questionnaire. Ajzen's conceptual and methodological requirements for creating a TPB questionnaire were taken into consideration when defining the questionnaire [12]. In this study, attitudes were measured by a total of four questionnaire items (e.g., GAPs will be able to increase aquaculture production), subjective norms by a total of six items (e.g., close families expect shrimp farmers to apply GAPs), perceived behavioral control by a total of three items (e.g., Confident that I can apply at least one of the many stages of GAPs), and behavioral intentions by a total of three items (e.g., Intend to implement GAPs (in full according to the stages). A total of 116 questionnaires were completed. Four incomplete surveys were eliminated, leaving a final sample of 112 respondents. Each item received a 5-point Likert scale score (1 = strongly disagree; 2 = disagree; 3= neutral; 4= agree; 5 = strongly agree). Table 1 is a compilation of the questionnaire items corresponding to the model variables.

The research hypothesis was tested by applying the TPB model, as defined by [12], where attitudes (ATT), subjective norms (SN), and perceived behavioral control (PBC) determine intention (INT). Based on the TPB factors, descriptive statistics were initially utilized to assess farmers' overall intention to implement GAPs. Then, in order to determine the relative significance of intention determinants in the under-consideration behaviors, a structural equation model (SEM) technique was applied to the data that had been collected. Unlike other approaches like multiple regression, SEM uses latent and observable variables to specify the model structure. The researcher cannot directly measure the abstract phenomena known as latent variables produced by the observable variables (questionnaire items) that are hypothesized and tested to quantify them. Confirmatory factor analysis (CFA) was used to determine the degree to which each questionnaire item (ATT, SN, and PBC) measures the same psychological concept [17, 18, 19]. The measurement model, in other words, shows the relationships between the latent variables and their observed measures. SEM deals not only with a single simple or multiple linear regression but also with a system of regression equations that allows one to examine the influence of several variables on several other variables according to a specified model. The relationships between the latent variables (the structural model) are formulated by linear regression equations. The relationships are graphically expressed by path diagrams using arrows (Fig. 2).

Cronbach alpha and factor loadings were used to establish the reliability of the constructs and various items. After that, to estimate the SEM models, both maximum likelihood and robust maximum likelihood procedures were applied. Finally, several model-fit indices were used to evaluate the model comprising p-value $\geq$ 0,05; the root mean square error of approximation (RMSEA) of < 0.08; the Tucker-Lewix Index (TLI) of ≥ 0.9; and comparative fit index (CFI) ≥ 0.9 [20,21,22]. The explained variance of the endogenous variable (i.e., intention) was calculated using the coefficient of determination R-square.

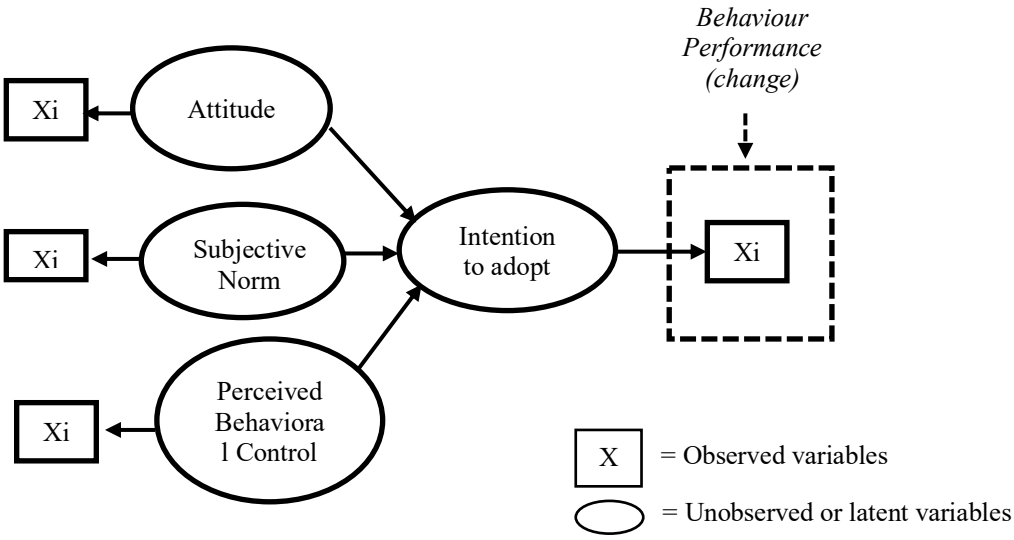

Fig. 2. The hypothesized SEM Conceptual model for estimating driving factors to adopt the GAPs scheme

3 Results and discussion

Table 1 presents the analysis results of the farmers' willingness to implement GAPs based on the TPB variables. Overall, based on the attitude variables, farmers' attitudes that GAPs can increase their production or income influenced the desire of farmers to adopt GAPs technology. According to [23], prices of aquaculture products and profit expectations are the main economic factors influencing adoption decisions. This analysis also showed that by adopting GAPs, shrimp farmers expect to increase their positive reputation in the community and improve the aquaculture environment. Regarding the individual perception variable (SN), shrimp farmers believed that the main impetus for adopting GAPs came from export or local entrepreneurs' direction; and assistance from relevant governments, and academics. In terms of perceived ability to implement (PBC), farmers felt they had sufficient knowledge and funds but only to implement or adopt at least one of the 18 aspects of GAPs, so financial assistance and assistance for maximum adoption are necessary.

Table 1. Results of descriptive statistics analysis of TPB-based driving and inhibiting factors affecting the shrimp farmers' decision to adopt GAPs.

Predictor variables	**Mean**	**Standard deviation**
A. Attitude (ATT)		
X1 = GAPs will be able to increase aquaculture production	3.7	0.62
X2 = GAPs will be able to increase farmer's revenue/profitability	3.6	0.56
X3 = GAPs will be able to improve their reputation in the community	3.6	0.58
X4 = Implementing GAPs will improve environmental quality (water/soil/mangrove etc.)	3.7	0.64
Subjective Norm (SN)		
X5 = Close families expect shrimp farmers to apply GAPs	3.5	0.64
X6 = Close friends (which is essential for the shrimp/fish farmer) will	3.6	0.56

share the same view that GAPs is a good and useful idea		
X7 = Entrepreneurs/industry expect farmers to implement GAPs	4.1	0.60
X8 = Consumers (local buyers) expect farmers to apply GAPs	3.9	0.46
X9 = The national and local government, environmentalists, and academics (universities, extension workers, or research centers) expect cultivators to apply GAPs	4	0.58
X10 = If in a position to choose the type of aquaculture technology that must be applied, I (the farmer) prefer to follow other farmers around the farming area	2.7	0.72
Perceived Behavioral Control (PBC)		
X11 = Confident that I can apply at least one of the many stages of GAPs	3.8	0.56
X12 = Have sufficient financial resources, land, manpower, and equipment to implement GAPs	3.3	0.73
X13 = Have enough knowledge (knowledge/information from training) to try or apply GAPs	3.3	0.60
Intention (INT)		
Y1 = Intend to implement GAPs (in full according to the stages)	3.7	0.57
Y2 = Will try to adopt at least one or two parts of GAPs.	4.0	0.60
Y3 = Plans to adopt GAPs	3.7	0.57

The interrelationship between attitude, subjective norm, and perceived behavioral control variables in influencing the willingness of traditional pond farmers to adopt GAPS can be seen from the SEM final model in Fig. 3. Of the 13 factors under consideration, 5 were excluded from the analysis because of standardized factor loadings lower than 0.5 [24]. Based on the analysis, all the absolute fit measures in this final model exhibited excellent goodness of fit: p-value Chi-square = 0.13 (>0.05), P-Value Satorra-Bentler Scaled Chi-Square = 0.44 (>0.05), CMIN/DF = 1.354 (<3), RMSEA = 0.069 (<0.08) and GFI = 0.920 (>0.9); and the relative fitting index, NFI = 0.930, CFI = 0.980 RFI = 0.900, IFI = 0.980, are all higher than the crucial value of 0.9, fully satisfying the fitting criteria. This indicated that the hypothesized conceptual model is confirmed or acceptable. However, most t-statistic values in the output model were lower than 1.96; and based on the standardized total effect, only the attitude variable had a positive value (0.31), indicating that the attitude of farmers' close families positively affected shrimp farmers' willingness to adopt the GAPs schemes. The path coefficients of subjective norms and perceived behavior control were -0.03 and -0.09, respectively. These negative values of path coefficients indicated that although the total effect was insignificant, subjective norms and perceived behavior control variables might negatively affect shrimp farmers' willingness to adopt GAPs.

The results of SEM analysis are generally in line with the previous descriptive statistical analysis showing the attitude variable as the best predictor among the two other TPB variables. According to [14,25], a belief that forms attitude is a determinant in the farmers' decision-making. [26] also found that a positive attitude that reflects awareness of the benefits will significantly affect the intention of smallholder agriculture in Northeastern Thailand to adopt a new technology or innovation. The result implies the importance of helping shrimp farmers recognize the technology benefits to increase the GAPs technology adoption. Therefore, there is a strong need for the role and encouragement of big industry, local entrepreneurs, and agencies to influence the willingness of GAPs adoption in traditional shrimp ponds. The SEM result also revealed that the traditional shrimp farmers still appreciate the importance of reputation in the community, significantly affecting the desire

and behavior to adopt GAPs. Shrimp farmers' attitude to adopting new technology is closely related to their positive perceptions, such as the ease of use, availability of applicable demonstration or pilot projects, and assistance from professionals (e.g., extension officers, researchers, or academicians). The result is also consistent with the study conducted by [9,27], who found that adequate technical and financial support policies, as well as extension services, should be encouraged for farmers; furthermore, it may be more efficient to encourage technology adoption by improving their education through training and retraining programs as well as removing insurance limits. For this reason, small-scale pilots applying the GAPs scheme can be crucial in inspiring shrimp farmers.

Considering the negative value of the standardized path coefficient for the subjective norm variable, which was attributed to the influence of local buyers (collectors) to implement GAPs, it reflects the reality of the current situation in the field. In practice, local shrimp collectors often act as a middleman. As long as the farmers can produce shrimp, local shrimp collectors in the study region generally do not care about the farmers' chosen pond aquaculture systems or techniques as well as the sustainability of the business, even if it is only for short-term profits. However, industries or international traders (exporters) will be more aware of the demands of some overseas consumers regarding product certification. Thus, the opportunity to influence the intention and adoption level can be encouraged through industries or exporters by means of technology assistance, access to funds, and marketing. However, the encouragement of industries can only be practical if the shrimp farmers feel it is more profitable to sell their product to the exporters than to the domestic market. Otherwise, encouraging GAPs adoption will be an added strain for the shrimp farmer [6,27,28].

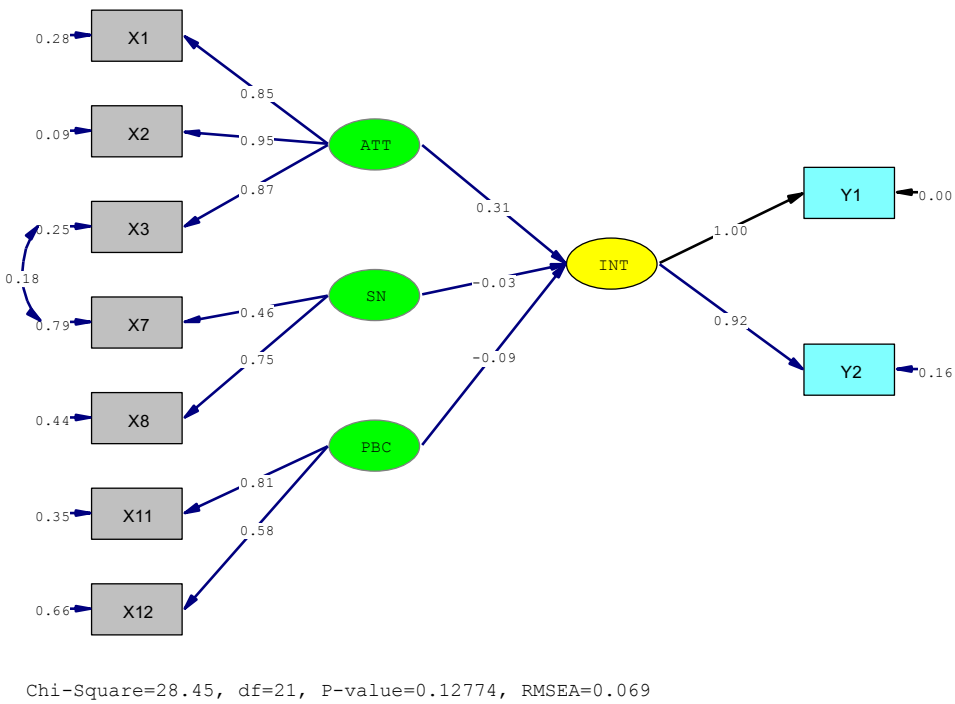

Fig. 3. Final structural equation model for the TPB with standardized regression weights

Further in-depth interviews with farmers during field observation revealed that due to existing technical and non-technical constraints that result in instability of both production and income, farmers in general only plan to adopt at least one or two parts of GAPs schemes. Farmers believe that to maximize the level of adoption and application, the existing production and farm management problems, such as the suitability of location; pond engineering, water quality management; and feed handling (use and manufacture), must be resolved to comply with GAPs requirements and guidelines. This assumption aligns with the existing condition of pond engineering and limiting environmental factors observed in both pond clusters. The current water quality problems were due to the difficulty of water exchanges in most aquaculture pond units. This situation caused pond drying failure during pond preparation and incomplete disposal of aquaculture waste after an operation [29]. Aquaculture ponds in the study are also built on sandy soils and have acid-sulfate soil characteristics that negatively affect pond production [30]. These pond engineering and environmental quality factors will be the main inhibiting factors for the implementation and adoption rate of GAPs in the study sites. In this case, technical assistance from fisheries extension workers, researchers, or academics is compulsory to direct them to comply with GAPs requirements.

4 Conclusions

The study successfully identified farmers' attitudes such as GAPs can increase their production or income; improve their positive reputation in the community; and help improve the pond aquaculture environment were the major driving factors to improve the adoption level. The encouragement and guidance from the aquaculture industry or entrepreneurs, academics, and researchers are the main impetus to adopt GAPs. This study also highlights the improvement of pond water and soil quality management; pond engineering in the study region must be highly prioritized to help improve pond production, which eventually increases the shrimp farmers' willingness to adopt the GAPs. It should also be acknowledged that the current results may not apply to other areas with different aquaculture problems. Therefore, further research in other regions is encouraged to explore more complex factors such as perceived ease of use, perceived risks, social networks, technology facilitation, household-specific factors, and self-awareness. TPB can also be integrated with other methods, such as the Technology Acceptance Model (TAM) and Importance and Performance Analysis (IPA), to enrich the analysis and get more practical insights.

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