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Integrating generative artificial intelligence into Bakaran Batik: effects on design and workflow efficiency

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ABSTRACT

Artificial intelligence (AI) has been used in the development of design motifs for Bakaran Batik. This study investigates the methodological gaps in the production process, especially in the early stages of motif design, where traditional methods require a long time to design motifs, making them ineffective for clients with high demand and limited time. Qualitative methodology was used to collect data from two cross-generation batik companies. The data collection process included interviews, observations conducted before and after the application of AI, and literature analysis. Since 2023, AI technology for motif design has been applied in the Bakaran batik industry. AI generative motif design simplifies the batik pattern design process, allowing for a more measurable production process in terms of batik production time. The findings show a significant reduction in the time required for design and an increase in motif diversity. Batik artisans in Bakaran responded positively to the use of AI because it showed an increase in motif diversity and did not replace labor-intensive labor. However, the use of AI machines in motif design is less appropriate for certain clients who prioritize the motif design process through local wisdom such as fasting rituals, meditation or special inspiration from their batik makers. The use of AI has an impact on the Bakaran Batik industry including the potential for the growth of an innovative and sustainable economic system for its craftsmen considering the rarity of the younger generation who are engaged in the batik industry in Bakaran. The integration of AI in the motif creation process allows the batik business to preserve heritage motifs while increasing work productivity and overcoming creative challenges during motif design. This initiative ensures the long-term survival and expansion of Bakaran batik in the digital era.

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1. Introduction

Bakaran Batik is a type of Batik in Indonesia developed since the 14th century AD in Juwana, Pati [1]. Bakaran Batik is classified as coastal batik with a tendency towards darker colors [2]. Bakaran Batik cannot be separated from the influences of Javanese Palace Batik, especially the classic Bakaran Batik motif which has some similarities with the Yogya and Solo style batik motifs [3]. Hence, the local craftsmen in Bakaran implemented and modified the motifs and techniques of palace batik. Furthermore, the movement of craftsmen and the interchange of creative concepts played a role in the prevalent features observed in this batik style. Bakaran batik incorporates a diverse range of patterns that draw inspiration from native plants, animals, and other natural elements. Based on the study conducted by Suyikno, E., Bain, B., & Suharso, R, several motifs have been established in Bakaran batik such as *Blebak Kopik, Blebak Urang, Blebak Lung, Blebak Duri, Kopi Pecah, Limaran, Gringsing, Manggaran, Gandrung, Sido Rukun,*

Bregat Ireng, Padas Gempal, Kedele Kecer, Rawan, Merak NgigeI, Liris, Magel Ati, Sido Mukti, Nam Tikar, Puspo Baskoro, Truntum, dan UngkeI Canthel [4]. Bakaran Batik moves with the times and constantly innovates to ensure its existence during changing times. This innovative development is carried out with workshops and partnerships involving designers and color specialists, the aim is to present new ways of coloring and color schemes [5]. Examples of developing these motifs are *Gelombang Cinta, Euphorbia*, and *Pati Bumi Mina Tani*. However, the methodology has obstacles such as initial resistance from conventional craftsmen who are used to deeper traditional visuals and new procedures that are difficult to adapt to. Despite these obstacles, batik makers have used this method effectively with the main aim of preserving and promoting Bakaran batik [4]. In order to advance SMEs, Batik Bakaran also implements Supply Chain Management. Through this approach, producers can better control work patterns and environmental factors [6].

Based on the studies of Rohmah, U., Kusuma, A. J., & Rohilie, F. The craftsmen also received training to increase batik innovation in terms of coloring, along with the development of nautical batik motifs that still maintain the characteristic of Bakaran Batik, namely coastal motifs/cracked motifs [7]. The impact is that batik makers are more agile in utilizing technology and meeting client requests. In connection with sales, marketing techniques such as digital marketing, product design, and online site placement have been implemented. To apply these techniques to achieve large sales growth, motif designs must be in line and integrated with trends, existing technology to communicate the recent design concepts [8]. Furthermore, Lestari's research with the SOAR (Strengths, Opportunities, Aspirations, Results) approach contributes to the creative realm. The SOAR method includes identifying the advantages of Bakaran Batik, namely its distinctive themes and cultural heritage, exploring market expansion possibilities, determining future growth ambitions, and economic sustainability. Supported by qualitative research methodology such as primary and secondary data sources, observations, interviews, and documentation, SOAR emphasizes the importance of the distinctive characteristics of Bakaran Batik and consumer-driven design in building excellence in the batik industry. To maintain strength in market competition, the characteristic characteristics of Bakaran written batik cannot be replaced [9]. The philosophical ideals of batik are increasingly weakening. This can be seen in several printed batik products which are produced massively with the same motif patterns and haphazardly just to meet market demand [10]. One of the most important components in increasing the selling value of batik is the batik design motif. One of the most important components in increasing the selling value of batik is its design motif. Therefore, to increase the selling value of batik products, the motif design must be improved while maintaining the labor intensity and artisan of batik making, so that the distinctive character of Bakaran Batik which is the hand-written batik method remains visible [11].

Based on current research, the efforts to improve the variety of Bakaran Batik design motifs are still done manually by prioritizing the artisan imagination [12]. It requires unpredictable time to create a batik motif and takes a long time affecting the sales volume of Bakaran Batik itself to less than optimal. Furthermore, in 2023 Bakaran Batik implemented the AI technology based on stable diffusion V1.4 that can generate the main motifs [13]. With Generative AI Motifs properly applied to Bakaran Batik, it will help and facilitate the development of Bakaran Batik in terms of its creative and economic aspects. Stable Diffusion is a generative deep-learning model that excels at producing high-quality images from textual descriptions more commonly known as text prompts [14]. Its adaptability and durability make it very suitable for applications that require detailed and culturally nuanced output, such as Bakaran Batik. The stable Diffusion V1.4 version model used in making the Bakaran motif shows superior performance in producing linear and detailed images, which is very important to maintain the authenticity and artistic integrity of Bakaran Batik. In order to preserve the cultural heritage of Batik Bakaran, it is crucial to carefully handle cultural factors during the use of AI. Incorporating the knowledge and skills of traditional artists into the AI training process is essential to ensure that the resulting motifs accurately represent the cultural and historical importance of Batik Bakaran. The AI machine currently used in Bakaran village has gone through the correct procedures. Furthermore, workshops have been held informally and formally in 2023 on collaborative sessions between researchers from universities through the Kedaireka matching fund program

and batik bakaran artisans facilitating the integration of technology and traditional practices. Moreover, continuous supervision and feedback from the artisans can direct the refinement of the AI, guaranteeing its compliance with the conservation of Batik Bakaran's cultural core. By effectively aligning technological advancement with the preservation of cultural traditions, Batik Bakaran can thrive in the present while maintaining its heritage.

The application of AI technology not only enhances the creative process of motif design but also honors the preservation and the archives of traditional motifs traditional motifs, many of which feature hereditary motifs in their designs. The use of this technology helps batik artists who are unable to draw and make manual motifs and avoid creativity blocks while designing the motifs [15]. The motif design produced by AI is then printed on tracing paper and the batik maker interprets the respective batik style on a sheet of cloth using the written batik technique. This AI technology does not replace the labor-intensive batik process. The AI method based on stable diffusion in Bakaran Batik will only be implemented in 2023. This new method is projected to shorten the workflow in batik production and accelerate economic growth. However, the use of AI technology at the motif design ideation stage in the Bakaran Batik production workflow needs to be studied for its impact. The aim of this research is to determine the effectiveness of using AI technology in helping design Bakaran Batik motifs and whether the use of AI threatens batik makers in the Bakaran area. This research uses a qualitative approach in collecting data and describing the information obtained. The impact of this research elaborates the change in the batik production workflow and the labor-intensive economy of the Bakaran Batik industry.

2. Method

This research was conducted in the Bakaran Wetan area, which already knows and uses AI technology in designing patterns. This area was chosen to observe the incorporation of contemporary technology into traditional craftsman skills. Burnt Batik motifs, which are complex and closely related to the visual environment, are the main focus in investigating the influence of AI on traditional art forms in the production process. Data collection carried out included interviews, observations, and literature reviews [16]. In order to obtain accurate data, researchers conducted interviews with entrepreneurs who are also pattern designers. Mr Bukhari and Mr. Sunaryo from Batik Tjokro, Mr. Bagyo from Batik Candrakirana was chosen as the in-depth interview sample because he is an entrepreneur, batik maker, pattern designer from a different generation and also produces his own batik. The interview method was carried out in Bakaran Village, Pati, Central Java Province, Indonesia, on August 2 2023 and November 13 2023. Observations were carried out at Tjokro Batik, the Candrakirana Batik production site, and the Sudewi Batik Museum. Observations are carried out in nature without any deliberate attempt to manipulate the surrounding environment, thus ensuring that the results obtained are unbiased. In addition, literature analysis methods are used to support observation and interview data. Triangulation methods are used in reducing and presenting results. Method triangulation is connecting cross-reference data obtained from different research methods. in this case it is interviews, observations, and literature analysis (Fig. 1). Furthermore, it explains the process of cross-referencing and combining several data sources to arrive at conclusions.

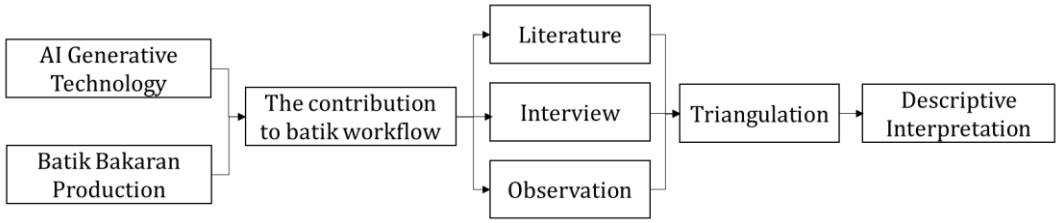


Fig. 1. Research steps

3. Results and Discussion

3.1. Original Method of Bakaran Batik Production

Based on the interviews conducted, Mr. Bukhari explained that the Bakaran Batik process is still traditionally done by drawing the designs by hand one by one on each cloth. He added that it takes up to 1 month to make a piece of cloth, this method can take up to months for a large order. Mr. Bagyo added that the batik's maker takes quite a long time to be inspired by the motifs they want to make. To get a certain motif, there are times when each Craftsman or artisan performs a ritual of fasting and meditation to get inspiration for motif ideas and the meaning behind the motif, or called *nyepen*. This is one of the unique things in the ideation process of Bakaran Batik workflow. Through observations at Batik Tjokro and Batik Candrakirana on the process of making Bakaran Batik, it was found that the process of making handwritten Bakaran Batik itself consists of 9 stages (see Fig 2), (1) the design phase is an ideation process that produces a core motif, after getting inspiration, the motif is drawn manually on around A4 size paper then developing into bigger transparent paper that fit into the fabric with scale 1:1. (2) the klowongan or molani process (drawing the motif based on transparent paper into the fabric), (3) followed by isen-isen (filling with cecekan/dot, sawutan), (4) then nembok put some parts without motif, covered with malam or hot wax. This is followed by (5) medel, the first phase of dyeing. Drying is followed by (6) ngerik and ngremuk is scraping and greasing, i.e. scraping the and washing it until it is clean from the malam, ngremuk is crushing the wax on the fabric to form a cracked texture which is the typical character of batik from the Bakaran area. Then it continues with (7) mbironi, repeating the pattern with wax, (8) nyogo, dipping the cloth in dark brown dye, and finally (9) nglorod, cleaning the wax that is still stuck to the cloth. The process of batik making itself is done by more than 1 person and takes between 4 days up to 1 month, depending on the difficulty of the batik.

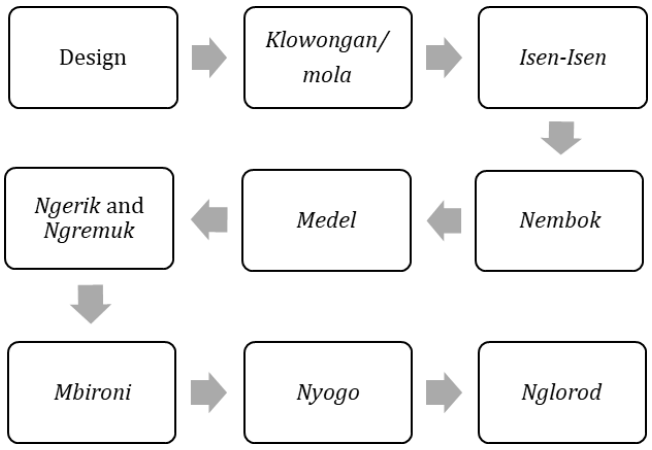


Fig. 2. Original Workflow of Bakaran Batik Production

Analysis of the results shows that although the traditional technique of Bakaran Batik requires a lot of time and effort, it also guarantees extraordinary creative richness and cultural authenticity. However, the obstacles that always arise are the long production duration and the need for the creativity of skilled craftsmen, which may be unexpected because it originates from a long ritual process. These techniques also emphasize the advantages of Bakaran Batik, such as its deep cultural importance and intricate artisanal patterns that are highly valued by certain customers. The combination of AI technology, especially the Generative AI model which relies on Stable Diffusion trained by local Bakaran motifs belonging to batik producers Mr. Bukhari with permission, can overcome the problem of long ritual duration but still maintain cultural authenticity. AI can improve the ideation stage by generating motif concepts derived from conventional patterns, thereby minimizing the time allocated by pattern designers to search for inspiration. However, this AI method does not have deep philosophical value like the patterns produced by the rituals and inspiration of batik makers. This technology has the advantage of optimizing the design process which is suitable for customers who request production with various pattern designs but in a short time. This AI-enabled pattern design method allows for

faster scaling and efficient implementation of motifs into fabric. Batik makers in Bakaran can integrate AI-generated designs while maintaining the fundamental aspects of traditional motifs and personal interpretation considering that the original patterns produced are only core patterns or *ceplokan*. The application of AI in the production process of Burnt Batik has shown good results because it succeeded in replicating the typical pattern of Burnt Batik. Informants reported a decrease in the time required to design and an increase in the diversity of motifs for batik production work and pattern selection with clients' time constraints.

This technological integration encourages long-term sustainability and expansion of the target market for Bakaran Batik in the contemporary era, as well as helping in the competitiveness of this craft. Based on literature analysis on the original method of making Bakaran Batik. According to Sugito, A. P., & Saputra, R., 2019, the process of producting Bakaran Batik begins with making a motif pattern on batik cloth (*molani*), then the batik pattern is painted with a canting (*ngengkreng*)., and then the ornaments are filled in with the various motifs that have been created. Next, the parts that do not have motifs are covered with *malam* or wax. After the first phase of coloring is complete, the wind is used to dry it, as it should not be exposed to direct sunlight. After drying, scrape and wash it until the *malam* or wax part is clean. After washing and drying, the pattern is repeated with wax *(mbiron)*. Then the fabric is dipped in dark brown dye *(nyogo)*. It is then repeatedly dipped in water to remove the stuck wax *(nglorod)*. In the final stage of the manufacturing process, the fabric is dried in the sun [17]. The production of Bakaran Batik Is rather a lengthy process. Therefore, an effective and efficient production process is required. Craftsmen or artisans have the capacity to fast for several durations, ranging from 3 days to 40 days. Following fasting, the artisans engage in meditation or make a retreat to seek inspiration or generate ideas for the batik patterns they intend to create. At some point, it is generally assumed that they possess a concept or visual representation of the motif they intend to create. Typically, these motifs depict the present condition of society and convey a moral statement to the community. Furthermore, many motifs also depict the artisans' background. Hence, each batik motif has a certain objective to be accomplished. The design process itself undoubtedly requires a significant amount of time until the artisans are able to find inspiration. In ancient times, craftsmen were required to perform a ritual as a preliminary step to establish the inspiration for the motif they intended to create. This is done because Bakaran Batik inherently possesses its own distinctive pattern and message.

Craftsmen must articulate their creative inspiration or concepts by means of motifs on expansive canvas paper. The typical production time for a single piece of batik cloth is from 20 to 30 days, variable by the intricacy of the design. Regarding bigger orders, this procedure can require a duration of several months. The stages of *nyepen* possess distinct characteristics and exhibit a significant cultural sophistication, whereas the emergence of inspiration is characterized by an unexpected timeframe. Despite its cultural significance and uniqueness, this approach was inadequate to meet the market demand for pattern design and production in a short time. The time-consuming nature of traditional procedures made it difficult to meet the rapidly evolving needs of consumers. In-depth interviews also explained about the interest among artists providing evidence of a decline in interest in Batik Bakaran. This reveals the fact that the younger generation is less enthusiastic in pursuing batik making as a main occupation, thus raising concerns about the sustainability of this art form. This view is renewed by Mr. Bukhari, who observes that without a successor, the intricate designs of Batik Bakaran face the possibility of being forgotten in the next few years.

3.2. Effectiveness of Artificial Intelligence Programs in Developing Bakaran Batik Motifs

After practicing the use of AI in developing the Bakaran Batik motif, interviews were conducted again to determine the effectiveness of AI. Mr. Bagyo and Mr. Bukhari explained that AI was very helpful for Bakaran Batik entrepreneurs in Bakaran village, especially for those who produce hand-written batik. Since batik writing is a complicated process for creating motifs, with the help of this Generative AI design, batik makers no longer have to do so many wasteful activities that take a lot of time. With the design of batik patterns by AI, batik can be mass-produced directly and also easily, on time, and in the right size. According to the interviews, the

Bakaran Wetan Batik Association can merge into a cooperative, and it becomes easier for batik makers to create designs that follow more spectacular patterns from the era without replacing the labor-intensive with AI in batik production. From an observation perspective, during the training of several Bakaran Batik artisans in the use of AI, these observations showed that the artisans were able to understand how to use the program. The process of motif generation is done by turning on the engine of the program, then entering the desired text and the program can perform the generative process for the motif. Moreover, the motif generation process is very fast and takes less than 5 minutes, depending on how many variations of motifs are wanted. Furthermore, the motif variations can be downloaded directly in PNG/JPG format by Bakaran Batik artisans (Fig 3). The downloaded motif variations can be printed by batik artisans directly by the *molani* stage.

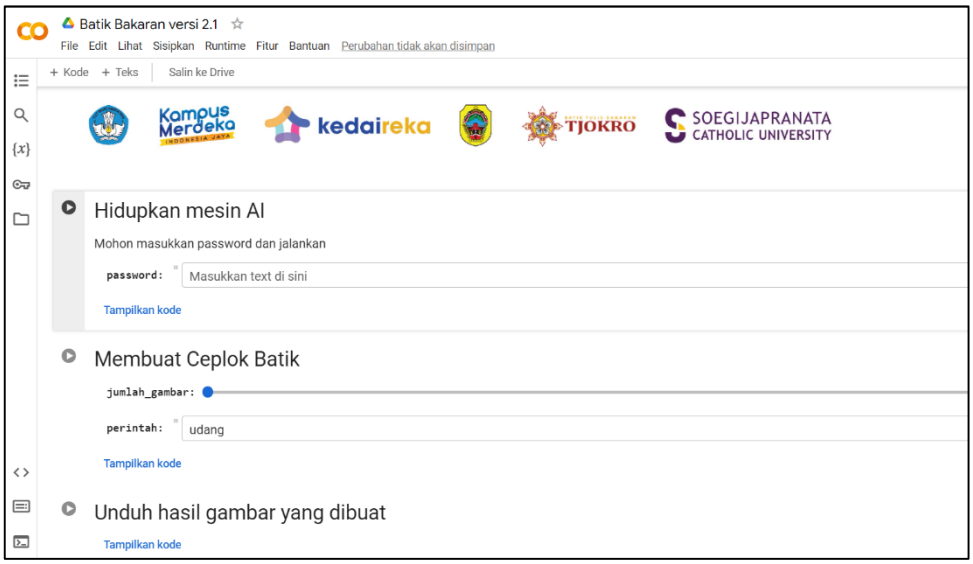


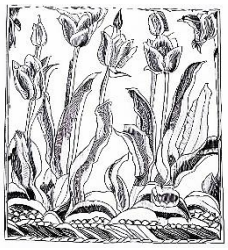
Fig. 3. The inference of AI-Generated Motif used in Bakaran Batik since 2023

According to Lee, S., *et al.,* an advanced text-to-image generation system with Stable Diffusion can synthesize images with high esthetic quality [18]. This is especially true when using modifications to change the style or improve the quality of the image. The use of stable diffusion in AI is certainly very useful to facilitate human work, especially in the creation of multiple works with the same characteristics like Bakaran motifs. The text-to-image generation method or generative deep learning can synthesize images with high esthetic quality, especially when modifiers are used to change the style or improve the image quality [19]. Generative deep learning is recommended in the ideation stage to avoid the creativity block. In this study, Generative AI based on stable diffusion helps to simplify and shorten the process of creating Bakaran Batik. By using AI, artisans can reduce the time it takes to create motif designs, making the process of making batik faster. AI also has the potential to helps artisans give an overview of the result of Bakaran Batik when it is used as clothing, it may help the buyer imagine the final product [20].

As shown in Table 1, the use of AI was implemented by Bakaran Batik artists in the Bakaran Wetan and Bakaran Kulon regions. In order to interact with the program, the craftsmen must access the specified website. The craftsman can thereafter input the text prompt representing the intended pattern in either Bahasa Indonesia or English, and indicate the desired number of motif variations. The AI inference (Fig. 3) enables the generation of 1-8 motif variations in a single session. Following the completion of the generation method, the preferred motif can be promptly downloaded as a PNG/JPG file and then printed on paper to be used in the klowongan/molani step. This procedure requires about 5 minutes. Typically, the themes produced have fulfilled the craftsmen's expectations in terms of their creative merit. Artisans have claimed that the motifs generated by AI offer novel and inventive designs while yet preserving the traditional spirit of Bakaran Batik. This has had a substantial impact on the quality of the motifs, as the AI is capable of generating intricate and culturally subtle designs

that conform to the artistic criteria of Bakaran Batik. Additionally, the utilization of AI has contributed to a beneficial cultural influence by preserving conventional themes and introducing novel adaptations that generate interest among contemporary customers. Accordingly, the use of AI technology has improved both the artistic and commercial elements of Bakaran Batik, so guaranteeing its continued significance and viability in the modern market. Referring to Fig 4., it can be seen that the use of AI technology can shorten the long design process to meet the buyer's needs. Moreover, the batik makers no longer need to manually draw their designs on A4 paper and the tracing paper as the designs can be printed directly on the tracing paper. Therefore, if large production quantities are required, the batik company can print the patterns in bulk so that the *molani* process can be carried out simultaneously. The use of AI can shorten the design phase for batik motifs and shorten the *klowongan/mola* phase on batik production workflow, especially for large orders

Table 1. Generate Stable Diffusion Results Example

Text prompt	Results 1	Result 2	Result 3
bird			
tarsier			
tulip			

The AI algorithm used for the development of the Bakaran Batik motif can be categorized as generative because of its ability to produce motif images and facilitate pattern development based on trained Bakaran Batik pattern style image data. This finding is in accordance with research conducted by Ardhianto and Nababan which discusses that AI, especially in the field of text-image production, has the ability to produce images that reflect given words or phrases based on specific trained data [15]. The application of AI technology allows Batik Bakaran artisans to significantly reduce production time, especially in the pattern design stage. Due to its short duration, the motif creation method allows for rapid mass production with measurable time. Artisans have stated that the motifs generated by AI provide a variety of creative possibilities, making it easier to explore new concepts and visual styles according to the batik artisan's version. The capacity to produce several variations of motifs quickly allows artisans to explore unique designs without a long ritual process for clients with short-term production requests. As a result, there has been a significant increase in efficiency and production, accompanied by a variety of items that are able to appeal to various market segments. The use of AI in the design process has enabled innovative progress and potential financial development for Bakaran Batik industry players, thus ensuring their long-term survival and expansion in the contemporary market.

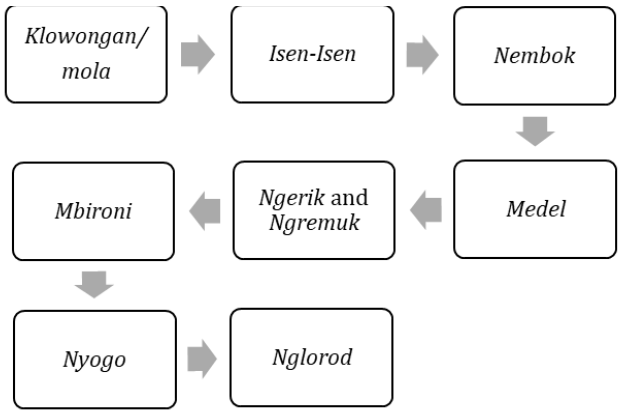


Fig. 4. Workflow of Bakaran Batik after using artificial intelligence

4. Conclusion

This study aims to examine the use of AI in the development of Batik Bakaran motifs which have an impact on the production process. The results of the study show that Batik Bakaran, a typical Juwana, Pati hand-drawn batik, uses a manual method in its production process. This manual process consists of 9 stages, starting from the batik motif design stage, klowongan or mola, isen-isen, nembok, medel, jerik & ngremuk, mbrioni, nyogo, and nglorod stage. The use of AI is only intended when receiving production and design requests in a short time. Previously, batik makers had to seek inspiration first by means of nyepen. In addition, batik makers must also submit designs to clients for approval before proceeding to the next stage. With the application of AI in the creation of Batik Bakaran motifs, craftsmen can enter command text and determine the number of motif variations desired. Furthermore, the selected motif can be downloaded and printed on paper to be transferred directly to the fabric. This greatly reduces the duration of the design process, because batik makers no longer need to invest a lot of time looking for inspiration and have a variety of easily accessible themes to propose to their clients. This has the potential to further increase the economic income of Batik artisans in the Bakaran area. However, the use of generative AI on Bakaran Batik motifs is not appropriate for clients with special requests that emphasize ritual and meditation values or certain designs from their batik makers. Throughout this challenge, AI assists in the process of generating motifs without replacing the tasks of labor-intensive hand-drawn batik workers.

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Declarations

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Conflict of interest	:	The authors declare no conflict of interest.
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