Empowering Mushroom Farmers through An Inclusive Mushroom House Design

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Abstract

As a part of the Agrilab Inclusive farming programme, Pusat Rehabilitasi Yakum collaborated with the Institute for Research and Community Service, Universitas Kristen Duta Wacana in assisting the design and development of the inclusive mushroom house which is owned by the farmers under the Yakkum Difable Person Organisation in Cangkep Lor, Purworejo. The design process was conducted by utilizing the participatory design method. The enquiry phase included the determination of the most demanding capabilities in the mushroom-farming context. The problems were mainly found in accessibility. For instance, the visually impaired farmer required non-visual stimulus. In addition, motion or space adjustment was also needed by wheelchair-using farmers. The action-research method in this programme intended to develop a mushroom house with adequate, accessible pathways and an automatic misting system that eased the difficulties faced by farmers with disabilities. The results showed that the solutions increased the productivity of mushroom farming, promoted a positive experience in mushroom cultivation both for farmers with and without disabilities. The participation of mushroom farmers during the design process was the key to the sustainable mushroom house. This approach allowed the mushroom farmers to understand the inclusive design principles and to adjust the design to meet their capabilities and local sources. Therefore, they could accommodate maintenance and implement future development independently.

Keywords: *automatic watering system; disability; inclusive design; mushroom farming; sustainable*

Introduction

Agrilab Inclusive Farming, particularly in mushroom farming was conducted by Yakkum Rehabilitation Centre or Pusat Rehabilitasi Yakkum (PRY) in a collaboration with the Institute for Research and Community Service, Universitas Kristen Duta Wacana (LPPM UKDW). It was in line with the third mission of UKDW which is to deliver a community service using a participatory approach. The involvement of disabled mushroom farmers in Agrilab activities is an implementation of PRY's mission to ensure services and the empowerment of persons with disabilities fulfilling their basic rights. Therefore, the programme should be conducted in a holistic and inclusive approach (Pusat Rehabilitasi Yakkum, 2021). The empowerment in the economic aspect of disabled mushroom farmers is part of the Difable Person Organisation (DPO) Livelihood Project programme. It refers to the Law No.8 of 2018 concerning Persons with Disabilities. The law states that the implementation and the fulfilment of the rights of persons with disabilities is based on the principle of their full and inclusive participation. This principle was applied in the design process of mushroom houses in the Agrilab programme in Purworejo Regency.

This Inclusive Mushroom House Agrilab community service involved DPO Restu Abadi in Purworejo which consists of 22 active members with various disabilities (i.e. Cerebral Palsy, Physical Impairment, Intellectual Disability and Visual Impairment) and their caregivers. The community cultivates Oyster Mushrooms (Pleurotus Ostreatus) as a common local food source. Despite their skills and the existing accommodations in mushroom cultivation, they needed a mushroom house which could accommodate extreme users, such as farmers in wheelchairs and the visually impaired (VI). These wide range of differences required the completion of different designs tailored to the needs of each person. Based on these needs, this programme aimed to help the disabled mushroom farmers through the inclusive mushroom-house design. It should accommodate the circulation of farmers in wheelchairs and the operation of automatic mushroom watering which could be carried out by VI farmers. The participatory design process of the mushroom house was the key in organising this Agrilab programme. The design team needed accurate information from mushroom farmers regarding the space requirements and technical constraints faced by the extreme users. This information could be obtained through the involvement of mushroom farmers from the beginning of the design process through to the prototyping stage. User involvement in the design process is in line with the Commission for Architecture and the Built Environment

(CABE) inclusive design goal of removing barriers that create undue effort and separation. Inclusive design allows equal, confident and independent participation in daily activities (Fletcher, 2006). Referring to the inclusive design goal, the new mushroom house would also meet the inclusive physical environment. An inclusive environment should be accessed and used by everyone, regardless of age, ability, or gender. Therefore, designers must be aware of the capabilities of different people and broaden the range of users of their designs (Scottish Association of Building Standards Managers, 2009)

In accordance with the 18 Stages of "Process for adopting a professional approach to inclusive design at organization level" (The British Standards Institution, 2005), this paper aims to fulfil Stage 16: "Document, share, publicize, and celebrate inclusive design achievement". Therefore, the benefit of this report could improve the performance of similar projects in the future. As for limitations, this project was conducted during the Covid-19 pandemic era. Additionally, the UKDW team and DPO Restu Abadi were located in different cities. These conditions restricted the meet-up schedule, survey time, and direct mentoring that affected the design and construction process.

Method

This Inclusive Mushroom-House Agrilab programme implemented the action research method. This method was needed to achieve the objectives of improving the situation of the organisation or the community involved in the service learning. According to MacDonald (2012) and Sugiyono (2015), action research is a social study by analysing the increased quality as a result of any intervention given into a particular social situation. Four stages of participatory action research were conducted in this programme: planning, action, reflection, and evaluation (Pain et al., 2010). These four stages can be seen in Figure 1.

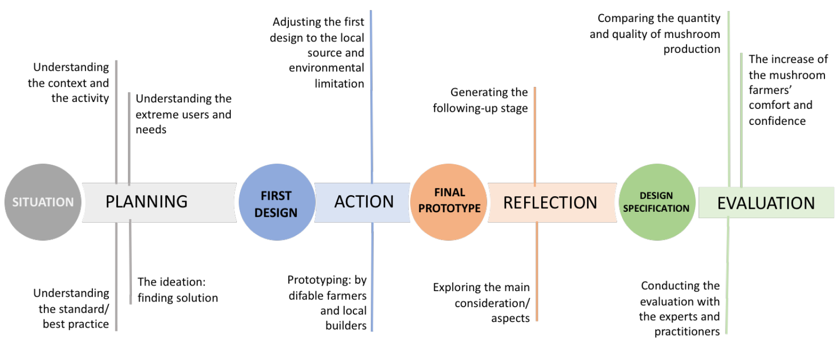

Fig. 1. The diagram of the process

Planning

Planning was carried out by Universitas Kristen Duta Wacana (UKDW) teams and Yakkum Rehabilitation Centre or Pusat Rehabilitasi Yakkum (PRY) teams by having presentations with offline and online discussions. The first meeting was held offline at UKDW to discuss the objectives, methods, participants and implementation of the programme. The second meeting was held online by involving the programme partners (i.e. the management of mushroom farmer groups in Purworejo Regency as the member of the Agrilab programme). The results of the activities at the planning stage became a guidance for the service-learning team to develop an inclusive mushroom house design plan according to the needs of mushroom farmers. Defining the needs and understanding the context becomes fundamental stages in an inclusive approach to determine the requirement of the problem solution (Keates & Clarkson, 2004).

Action

The implementation of the action phase consisted of five stages: field survey, design, Focus Group Discussion (FGD), design revision and implementation. The field survey was carried out by observing the dynamic situation of a design thinking workshop for the disabled farmers organized by PRY and visiting the existing mushroom house. The design phase was the stage of processing survey results and interviews which potentially determined the inclusive mushroom house criteria and design alternatives. The FGD involved the community-empowering team, PRY and mushroom farmers to collect criticism and suggestions for improvements. Design revisions were made based on the results of the FGD. The revised mushroom house design was used by mushroom farmer groups as the reference in the construction of inclusive mushroom houses. Supporting infrastructure was installed with the assistance of the community-empowering team.

Reflection

The reflection stage aimed to review the implementation process, activity results and follow-up plans for the sustainability of the programme.

Evaluation

The evaluation stage was needed to obtain feedback from the disabled mushroom farmer group assisted by Agrilab PRY and mushroom cultivation experts to assess the results of the mushroom house designs and mushroom watering automation systems.

Results and Discussions

Planning

The planning stage began in early September 2020 when the PRY team contacted the UKDW community-empowering team to support an inclusive mushroom house design project for disabled mushroom farmers in Cangkep Lor Village, Purworejo. On 16th September 2020, an online discussion was held between the three parties. At the meeting, the farmers presented the existing condition of the mushroom house, the management of the mushroom farm and procedures. Some potential problems were revealed, for instance: their need to achieve easy watering procedures, particularly for farmers who were totally blind and farmers in wheelchairs. Problem identification was obtained in a participatory approach of mushroom farmers as the Restu Abadi DPO members. The problem identification stage (observation) was conducted using the principle of empathy for extreme users who have more complex needs for accessibility to mushroom cultivation and care (Lewrick et al., 2020).

In the understanding of the extreme users' needs, it was found that the main problems in mushroom cultivation were the watering procedure by the VI farmers and the accessibility of the farmers in wheelchairs or with walking aids (e.g. crutches) to do the maintenance and harvesting. Under the team's assistance, the mushroom farmers did the analysis by comparing the result of the benchmarking stage and the reference (i.e. media and the best practice). The misting method was chosen by the members. As a result, the members also needed an adequate planning and implementation of the misting system and the environmental accessibility of the mushroom house.

Fig. 2. Learning from the best practice: Sedyo Tani Mushroom House

The UKDW team gathered data to support the design reference, such as the criteria of the user circulation which supported mobility assistive devices, principles to create an ideal mushroom cultivation environment and the misting technology to make the watering procedure become a positive experience for VI farmers. In addition to the literature studies, a precedent survey was conducted at Sedyo Tani Mushroom House, Bantul, on the 6th October 2020 (Figure 2). This survey was conducted to complement the mushroom cultivation study obtained from the experts in the mushroom research study, the Faculty of Biotechnology UKDW. Sedyo Tani Mushroom House was chosen as the best practice because it has implemented misting techniques since 2015. It also has the same environmental conditions (i.e. humidity and weather) as the current programme (Lestari et al., 2015). Sedyo Tani Mushroom House design gave confirmation of the mushroom cultivation study data that had been gathered before, such as: (1) a hardened floor to prevent pests from the soil gaining access to the baglogs. The design of the floor surface should be created in such a way to prevent flooding and allow water to egress from the building easily; (2) the permeable wall that protects the mushrooms from insects entering the facility also provides air circulation to avoid excess humidity; (3) a roofing material that protects the mushrooms from excess heat. From the Sedyo Tani's experience, the team learnt the limitations of the misting system (i.e. material, infrastructure, logistics, procedures and costs) as part of the sustainability aspects.

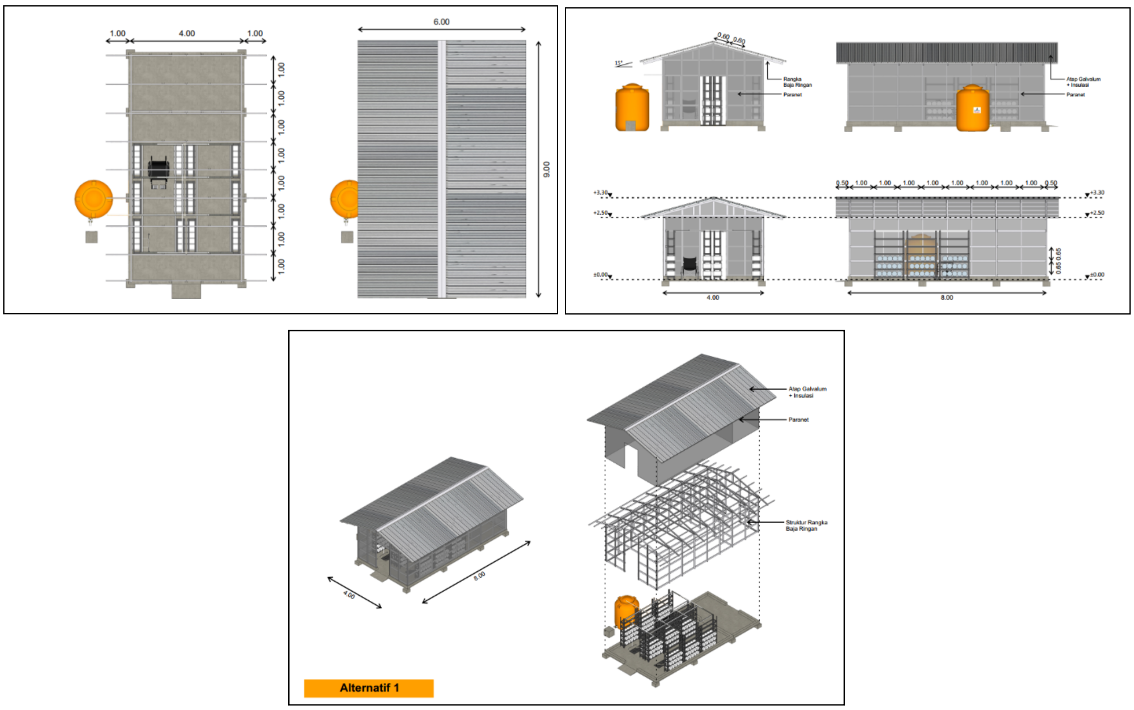

Fig. 3. The early design of the new mushroom house

Through this study, it was learned how the misting system and the most suitable components would be set up according to the experience of the Sedyo Tani Mushroom House, as shown in Figure 2. The UKDW team then proposed an initial design as shown in Figure 3. Two mushroom house designs were demonstrated with similar layout designs. The difference was the first design used building materials similar to Sedyo Tani Mushroom House which were a light steel structure and a light metal roof (galvalume) with heat insulation attached underneath. The second design used a wooden frame structure material. In the both designs, the distance between the mushroom baglog racks was 1.2 meters wide to give easier passage for farmers in wheelchairs, and a ramp was installed at the entrance to facilitate access to the mushroom house if there was a difference in floor height.

At the side of the mushroom house design, the floor and walls were adjusted. The floor was designed using cement pavement which aimed to prevent insects and other animals from under the soil from rising to the surface inside the mushroom house. This strategy also would disrupt the growth of mould. On one hand, the enclosure walls used a double layer of shading net (i.e. paranet) to support easy access of air and stabilize the humidity inside the mushroom house. On the other hand, it also prevents insects and animals from entering the building. In addition, the rack design was designed to only accommodate one mushroom baglog (Figure 4) to accommodate the VI farmers so they would have no difficulty in collecting damaged mushroom baglogs (e.g. due to mould) and replace them with new ones. Mushroom was grown inside the baglog filled with fertilized wood dust composition. Traditionally, the rack would hold two to three stacks of mushroom baglogs. As shown in Figure 4, at the top of the rack was added a transverse structure that will support the fogging hose, as well as a vertical watering rail with water holes adjusted to the height of the baglog rack.

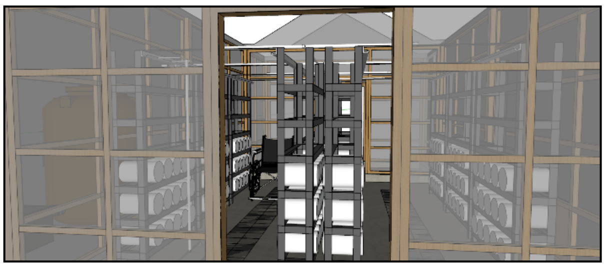

Fig. 4. The earliest structure proposal of the misting system for one level mushroom baglogs

The initial design proposal was presented in front of the mushroom farmers and the Agrilab PRY team on 27th October 2020. This design received constructive criticism to adopt a bamboo design to meet the material that could be sourced locally. In addition, the proposed cost of the lightweight steel structure is not cheap, so the UKDW team has responded favourably to this revised proposal. The structural design was then adapted to utilize bamboo. The misting system has received good responses and interest from mushroom farmers in Cangkep Lor Village for its simple procedure, easy maintenance and affordable price. Following that, the team and local farmers had to make sure that the system components should be easily sourced, applied and within an affordable price to meet the minimum capabilities of the farmers.

A follow-up meeting was held on 18th November 2020 between the UKDW team and stakeholders (i.e. YAKKUM and DPO Restu Abadi members). At this meeting, the design of a mushroom house with a bamboo structure as shown in Figure 5 was presented. The discussion also clarified the findings on the specifications for the misting system and the accessibility of the mushroom house; and also the potential independent and participatory implementation of the mushroom project. Examples of hose components and misting nozzles were also brought and shown to the mushroom farmers in Cangkep Lor Village. They gave a positive response regarding the fogging system that would meet the minimum visual and physical capabilities of the disabled farmers.

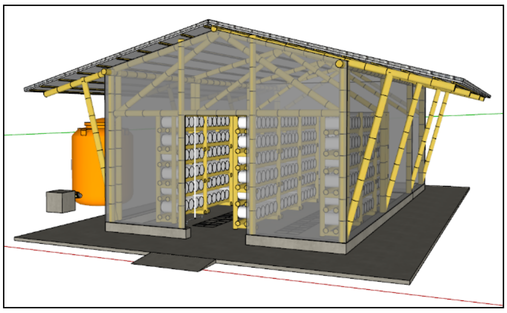

Fig. 5. The bamboo structure of the mushroom house proposed by the team

In its development, the UKDW team was given further information regarding the site conditions where one side was directly adjacent to the residents' houses and the other side was adjacent to the village road so that the building design needs to be adjusted (Figure 6).

Fig. 6. The original mushroom-house

The design was revised to be presented at the FGD which was held at the Cangkep Lor Village Hall. The structural design adjustments are shown in Figure 7, where the roof system was only one side with a bamboo structure and clay tile roof.

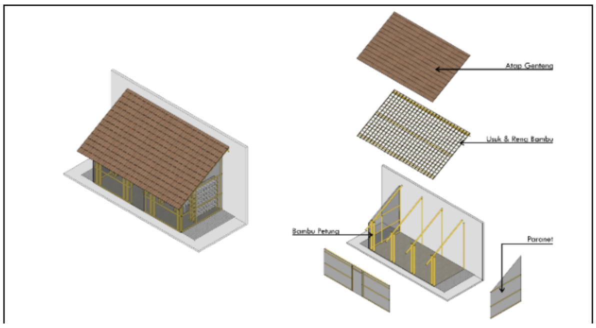

Fig. 7. The mushroom house's design with one-side attachment

In addition, two alternative layouts for mushroom baglog racks were proposed. The first design was longitudinal arrangement of Alternative 1 and 2 (Figure 8). The advantage of this design was it would increase capacity. The disadvantage was that access was clogged on each shelf-path so that human movement would not be easy. The second design provided transversely of Alternative 3 (Figure 9). The negative aspect of this arrangement was the smaller number of shelves. However, the access to treat the mushrooms becomes easier.

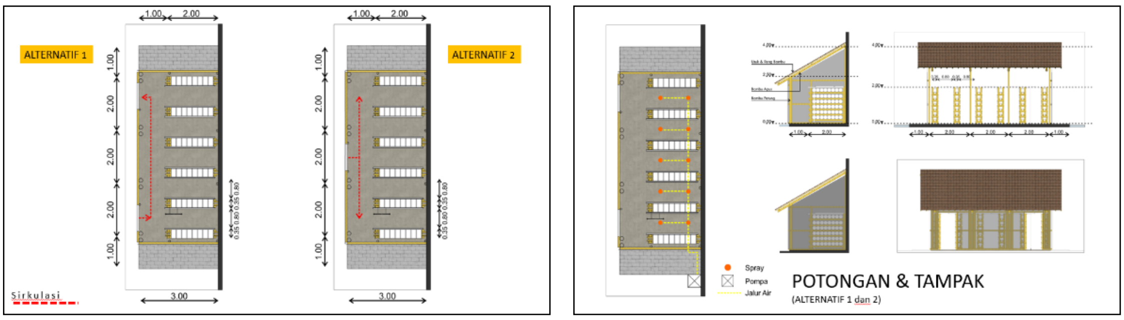

Fig. 8. The alternative of longitudinal arrangement

The FGD with DPO members (disabled mushroom farmers) was held on 23rd November 2020 in two sessions. The first session was grounding the knowledge about the inclusive specifications of mushroom houses. In this session, the UKDW team explained the principles of mushroom house design in an agricultural management aspect, inclusive perspective and some examples of their implementation on the proposed design.

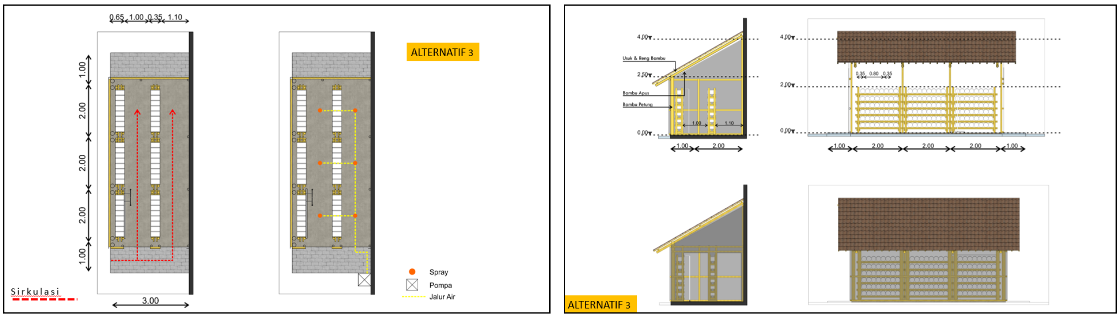

Fig. 9. The alternative of transverse arrangement

Action: Design and Implementation

The result of the planning stage demonstrated a mapping of natural and human resources; and adjustment of inclusive specifications with resource availability and behaviour of mushroom farmer members (Table 1).

Table 1. The adjustment of the standard to the potential environment and source

Aspect	Best Practice	Current
Material	Galvanized material was used to improve the structure's integrity and durability of the mushroom rack	Long 'Petung' bamboo material was available around the site so costs could be reduced
	White PVC pipes used in the misting system	Procurement of PVC pipe logistics and construction of misting systems would be difficult with limited individuals and the physical capability of local farmers
	The walls of the mushroom house should block direct sunlight but still provide adequate ventilation	Procurement of mulch sheet materials will burden the members because of the cost
Layout	The short (longitudinal) mushroom rack layout made it easier to identify damaged baglog's location for farmers with VI	Harvesting would be easier if the layout of the mushroom rack arrangement was elongated and in turn minimised the effort required to cut long bamboo sections
	The misting system was placed on the roof, 50 cm above the height of the rack so that the mist distribution is even	Members could only carry out self-repair within hand's reach

The findings from the FGDs can be categorized as follows: The available land for the mushroom house was 3x6 meters. It was designed as an extension of the side of a house. The remaining design from the initial proposal included the procurement of cement floors to maintain the health of the fungus and the humidity of the mushroom house and the misting system with a selection of materials and components that support easy installation and maintenance. The mushroom house was built in mutual cooperation by disabled mushroom farmers and the locals using local bamboo materials (Figure 10).

Fig. 10. The material preparation by local farmer to build the new mushroom house

The construction of the mushroom house was carried out independently by DPO members and the local community with UKDW team's supervision. The selection of the pneumatic nozzle system (Figure 11) for misting was done by the team considering intuitive installation requiring minimum motor capabilities and online procurement (via e-commerce). This system has six important components:

1. Pneumatic slip-lock nozzle, this component has a gear mechanism to bite the PU hose so that water would not seep out. This system allows the user to easily pull the latch and position the hose. The results of the survey conducted by the team found that leaking was one of the biggest problems with PVC pipe materials. The non-pneumatic nozzles which had to be set into the pipe with PVC glue. Overtime, the adhesive joint would be degraded. The leaking due to age of use could damage the mushroom baglog. The sizes 0.2 and 0.3 mm nozzle were chosen because they produce a gentle mist within a radius of 0.7-0.9 m with low water pressure (80-150 psi).
2. Pneumatic slip-lock connector, the connector mechanism is the same as above. The connectors in this system come in many variants: joiners, T-connectors (tees), connectors for switching multiple hoses (5-way), elbow connectors, cross connectors, two-in-one

connectors (Y). This system provides flexibility for the user in designing and troubleshooting.

3. Six mm slip-lock Polyurethane PU hose, this hose has flexibility and dimensions that allow the user to only use simple cutting tools (e.g. scissors). This convenience is especially important for users who have limited hand motor skills. Compared to PVC pipe materials, hose fitting in this system does not require any other reinforcement (i.e. PVC glue) and is easy to store. This will support sustainability in the systems maintenance. The black colour was chosen to avoid the growth of moss on the body of the water channel (i.e. hose). From field studies on white PVC pipe systems, the team found that moss would tend to grow. This may affect the health of the fungus.
4. Low pressure pump (80-150 psi), this system makes it possible to use a pump that is more portable and affordable. This pump can be easily operated and needs minimum maintenance. This pump is equipped with a water filter to help channel water from the water reservoir which is placed below ground level so that the water quality can be controlled by the user easily. This type of pump is able to meet the distribution needs of a 3x6 m mushroom house.
5. Supporting humidity (i.e. automatic timer and hygrometer), humidity is an important factor in mushroom cultivation. An automatic timer that is connected to the pump and electricity, will make it easier for users to do watering. Users can periodically control humidity.

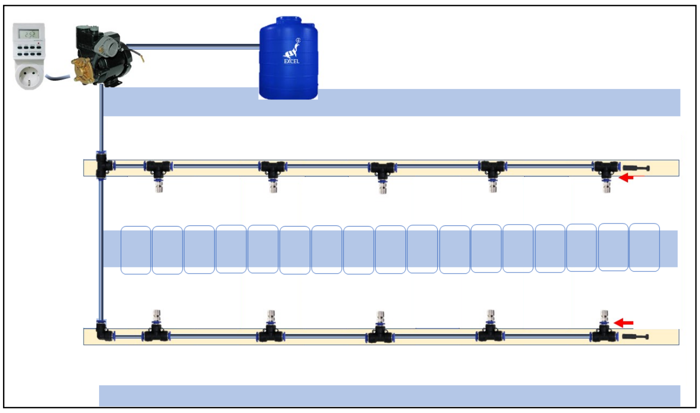

Fig. 11. The simple visual instruction of the spraying system for the local farmers

After the construction of the mushroom house and shelves were nearing completion (90%), the installation of the joining installation is carried out quickly (approximately 45 minutes) in several stages: (1) giving the schematic (Figure 11), to the active members (2) preparations were carried out in a timely manner by working together, both men and women, namely:

filling water, installing pumps, cutting hoses per 1m, cutting tie wires; (3) installation. The installation process was quick due to the installation procedure and component design in this system being intuitive. After installation, the members carried out the adjustment and finishing of the mushroom house independently (Figure 12).

Fig. 12. The installation of the spraying system by the local farmers being mentored by the UKDW team

Reflection

Herriott (2013) concluded that the academic record of inclusive design process mostly did not report the effort done in the design process so the audience could understand the turning points from the initial plan to the executed solution when the users participated. Therefore, this report tries to deliver the adjustment meeting user capabilities, perception, cognition, practical and social acceptability. From this community empowering activity, several interesting things were found: First, that this participatory service process could be considered successful. The design submitted by the UKDW team was not immediately accepted by the local community. In the development process, all design adjustments were made by the mushroom farming community of Cangkep Lor Village. For example, the slope of the roof of the mushroom house was opposite to the direction of the roof of the existing building next to it. It was in contrast to the UKDW design proposal. It referred to the idea of responding to the low mushroom house's entrance when the roof slope was extended from the existing roof (i.e. the house next to the mushroom house). However, it led to the following suggestion of UKDW team that the farmer's design would allow rain to flow from the road which is not good for fungus growth. In responding to the suggestion, the locals had an idea to use a tarpaulin banner belonging to the PRY Agrilab team to cover the open side in minimising the rain spilling out into the mushroom house.

Second, this participatory decision led to the contextualisation of the design to the sustainability aspect. One of the decisions such as choosing bamboo as the main structure shows sustainability problem solving. The expenses can be reduced by using bamboo that grows in Cangkep Lor Village which could be harvested for free. Likewise, labour costs could be reduced because local residents are very familiar with bamboo construction. This also demonstrates the principle of sustainability because, in the future, mushroom house maintenance could be done independently with the existing skills and local materials that are easily obtained at a low cost.

Fig. 13. The current mushroom house

Third, that this success is also supported by the existence of key people who become a mediator between those who provides service and the community who needs capacity building. In this case, the mushroom farming community of Cangkep Lor Village has members who were also persons with disabilities who mediate discussions between the disabled farmers, UKDW team and Agrilab PRY. They also spark ideas and empower the community to ensure the success of the project.

Fourth, the participatory process, that was also similar to the codesign method, gave a more suitable design for the community. As the team found that the design adjustments done by the farmers showed a better impact on the sustainability of the mushroom house. As for the community capacity, the teams encouraged them to apply this idea to the construction process. The teams act as advocates: explaining possible problems and impacts that might happen as a result of the design and letting the community propose the solution to avoid them. This method creates a practical application that is very convenient for the community because their solutions mainly were based on what they already knew and already had. The community also tend to favour the final design solution, probably because it was based on someone they knew and embodied the experience they had to achieve it (Luck, R., 2018, pg. 116). These conditions confirm the finding of Trischler et al (2018) that codesign can generate concepts that score significantly higher in user benefit. However, Trischler et al (2018) also found that the codesign method delivers novelty but lower feasibility which is different from the participatory mushroom design in Purworejo. Solutions delivered from DPO Restu Abadi community mostly have less novelty but higher feasibility.

Fifth, the whole design process with the participatory design method has helped the team to meet some important stages of the "Process for adopting a professional approach to inclusive design at organization level" by The British Standards Institution (2005), especially in Phase Two: "Establish foundation/Get into gear" and Phase Three: "Implement changes/ Determined impact". Referring to these stages, codesign and construction process with DPO Restu Abadi had shown the application of Stage 8: "Communicate the essence of philosophy, objectives and change programme, Stage 9: "Promote inclusive design nurturing culture", Stage 11: "Draw up a master programme of inclusive design work", Stage 12: "Bring together and develop inclusive design expertise, and Stage 13: "Implement programme and support new orientation to inclusive design". The next section, D. Evaluation, will explain the result of the last stage in Phase 3, Stage 14: "Evaluate progress and contribution of programme". By publishing this paper, the process can continue to the last phase, Phase Four: "Consolidate expertise & benefits/refine approach", and fulfil Stage 16: "Document, share, publicise, and celebrate inclusive design achievement".

Evaluation

Evaluation is obtained on two occasions. The first evaluation was carried out in the 2nd month after the construction of the new mushroom house design to obtain stakeholder feedback, which were: the cooperation partners (a group of disabled mushroom farmers assisted by Agrilab, PRY), and mushroom farmer practitioner Sedyo Tani to assess the results of the mushroom house design and system. The mushroom watering automation was also exhibited on a virtual expo (more details: https://bit.ly/AgriLabIndoExpo). The results of this FGD indicated that there was problem solving by applying inclusive design criteria (Keates and Clarkson, 2003). An inclusive design or system must accommodate user aspirations and user needs according to the user's perception and thinking ability. It also should consider the user's motor function, be practically accepted by the user and support users' social acceptance. In post-installation development, extreme target users could adapt and use the misting system easily. In addition, other users (i.e. a mother of a child with Cerebral Palsy) can comfortably grow mushrooms in her limited time which is affected by the intensive care requirement of her child. The growth and quality of mushrooms is more controlled because the user does not need to go in and out of the mushroom house which could disturb the growing environment. This system is able to eliminate the possibility of the entry of microorganisms or other actions that can interrupt the growth of mushrooms. The system also could easily be understood and carried out independently by all members. Despite of all of these conveniences, members are interested in mushroom cultivation because of the large potential and market.

The second evaluation was carried out in the 12th month after the construction of the mushroom house to see the sustainability of the new system through interviews with DPO supervisors. The findings of this evaluation describe:

1. Improved Mushroom Quality and Quantity

   By changing the old mushroom house design (i.e. soil floor and manual watering) to the new mushroom-house design, the mushroom harvest increased by 25%. The improvement of mushroom quality was demonstrated by the quality of the mushroom stalk, which was stronger. In addition, the mushroom body was larger, so it was not easily broken. Mushroom growth was stacked up to three levels and there was no rotten baglog. In the old watering systems (i.e. with hoses and medium pressure water pumps), baglogs tend to get wet and the stems of the mushrooms were brittle due to water pressure so that many mushrooms fell to the floor resulting in reduced yields (Figure 14).

2. Improved perception

   At the beginning, low perceptions of this system were found among members because the misting system was easy. Until the first harvest (before the baglog's ring were removed), the increase in mushroom harvest was still not significant. This was subjectively assumed due to the adaptation and residue of the cement floor. The significant changes occurred when the ring was removed. The mushroom harvest increased as described in point 1. The level of procedural difficulty and accessibility was accepted as not always linear with the output qualities. Ease of use occurred as a solution to the accuracy and suitability of the user's capabilities.

3. Increased self-actualisation

   Based on testimonials, the construction of mushroom houses with a misting system was still a pilot in the Purworejo area. The success of increasing mushroom harvests has attracted mushroom farmers who have been absent due to time constraints. It also became of interest to other communities. Mushroom farmers who were actively involved became resource persons at Village Disability Groups (KDD) in other areas. This finding supports the last level of inclusive design that accommodates social acceptance and self-actualization.

4. Adjustment of initial procedures as needed

   The unstable weather in the mushroom house construction area meant that the humidity control system (i.e. separate timer and hygrometer) was not used according to the initial design. Fogging that was set for a certain duration (i.e. 1 hour) sometimes was not suitable for cloudy weather, and vice versa. This caused baglogs' conditions to be too moist or too dry. In response to this, activation and disconnection of the misting system was still done manually. Given the mushroom house's condition in this project, the 0.3mm nozzle sprayer was found to be the most appropriate as it did not cause any problems and provided just the right amount of moisture. On the other hand, within 12 months, the 0.2mm nozzle sprayer was already clogged. Intensive treatment has not been carried out.

Fig. 14. The increased growth performance (taken before the first harvest)

Conclusion

The PRY-UKDW Agrilab mentoring project was carried out under a participatory approach. Conducting an empathetic problem-finding on extreme users was the correct strategy. The role of academics was providing a grounded understanding of the appropriate design standards and criteria to address user needs, directing the ideas of the members involved so that they can be implemented in an inclusive approach. The results of the current project showed that the automation of the watering system can potentially increase mushroom productivity and provide a positive experience for mushroom farmers in the ease of mushroom cultivating procedures, whether they have any limitations or not. Positive experience is defined as (1) the conformance of the design and system to the user's capabilities and needs; (2) self-actualization in a social environment (i.e. independence and contribution). The involvement of mushroom farmers in every stage of the design process is the key to the sustainability of the mushroom house. Mushroom farmers could recognise the principles of inclusive design to make design adjustments according to capacity, context and resources so as to facilitate the maintenance and development of mushroom houses in other places independently.

Acknowledgments

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