Farmers’ conservation behavior in Solo Hulu Watershed

S Anantanyu*, Suwarto, J Winarno, A Wibowo and P Permatasari

1Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami No. 36 A, Kentingan, Jebres, Surakarta, 57126, Indonesia
*Corresponding author: sap_anan@staff.uns.ac.id

Abstract. Watershed management is an important aspect to support the preservation of surrounding area. The function of upstream area as water catchment area should be protected by keeping the utilization of area from support capability surpassing the environment. Community participation is very necessary to maintain the environment in the ecosystem. This research will provide information about anything related to the profile of farmers, farming, and farming system in Beruk Village. Research is means of providing sustainable livelihood farming programs very useful to the farmer community. The research method used was case study, in which data was collected through in-depth interview, focus group discussion and participatory observation. Participative approach was conducted through in-depth interview, observation and involving farmers in Forum Group Discussion (FGD). The result of research showed that to minimize landslide in the farming area, farmer communities in Beruk Village always consider soil cultivating technique and irrigation system. Irrigation system organization is the farmers’ way of maintaining their land preservation. Farmers do not plant their land with big trees because they are afraid that the trees will shade their vegetables and lead to the death of vegetables. Local leadership in Beruk Village can be seen from presence of community leader.

1. Introduction
The damaged watershed should be overcome immediately. The function of watershed as water catchment area should be maintained to keep the utilization of area from the support capability surpassing environment, thereby to avoid land degradation. Watershed management is not merely about managing natural resource, but also managing human activities impacting the preservation of natural resources existing. The upstream watershed becomes the focus of management planning as it functions as water recharge areas. Watershed management, in reality, often encounters conflict of interest with and the land and resource utilization oriented to sectoral interests and different perceptions of the parties [1]. People in upstream watershed area pay less attention to their land’s support capability. Economic factor is the main reason for the inhabitants to do so, thereby resulting in environment imbalance and in turn generating land degradation [2]. Watershed management, using participatory and collaborative management based on land and water conservation principle, is an activity needing to do. Farmer communities (land owner or tenant) are those mostly knowing the condition of their cultivation land and mostly entitled to determine the management pattern done [3]. Public awareness is needed in preserving the environment and protecting water sources. If this can be done, we can reduce the impact of climate change. Land and water conservation program in a region can be successful when it is integrated into local community’s interest. This community participation can grow and develop when there is an attempt of improving the people’s knowledge and awareness of
the importance of conserving land and water resources. It is in line with suggesting that individuals’ participative behavior in watershed management is affected by social capital existing [4].

Beruk Village is one of the villages located in Jatiyoso Sub District, Karanganyar Regency, in Solo Upstream Watershed. Upstream environment, is the main part of upstream area’s complex system constituting the primary source of ecosystem service and storing water to prevent flood in downstream area [5]. Majority Beruk villagers are farmers. They cultivate the land on the area with high declivity. Land cultivation on high declivity is vulnerable to landslide. The Chairperson of Regional Agency for Disaster Management (BPBD), Nugroho, said that Karanganyar is vulnerable to landslide and belongs to landslide-red zone (solopos.com accessed on 6/09/2020). The problem of farming management in Watershed area is an important issue and needs serious attention. Stating that in watershed management, coordination and role played by all sectors and parties in cultivation are essential [6].

This research will provide information on many things related to farmer profile, farming, and farming system in the research site. Beruk village has over 15-degree declivity, so that it should not be planted with seasonal plant and should be the conservation area with perennial plant. Such condition is ignored by Beruk Villagers who have not been aware of the attempt of conserving land to avoid the incidence of such disasters as landslide. The participative approach makes this research a learning and self-development media in the attempt of satisfying the people’s life needs.

2. Method
This research was conducted in Beruk Village, Jatiyoso Sub District, Karanganyar Regency. Beruk Village was selected to be the location of research because this village lies in the east upstream area of Bengawan Solo Watershed. This research uses a qualitative approach. The technique needed to collect data was carried out with interview guidelines. The information selection was adjusted with snow ball method moving from one informant’s information to another. Data source was obtained from some informants: farmers, farmer group administrator, and community leader. The method used is a case study, in which data collection in this activity was conducted using in-depth interview, questionnaire, focus group discussion, and literature study techniques, each of which can be elaborated as follows:

2.1. In-depth interview, in which data is collected by asking directly the informants. This in-depth interview method is expected to obtain primary data related to this research and to get obvious description in order to facilitate and to analyze the subsequent data;
2.2. Questionnaire, a technique of collecting data conducted systematically through question list;
2.3. Focus Group Discussion (FGD) is conducted intensively to obtain certain data to be discussed;
2.4. Literature study is conducted by collecting data related to the research to be analyzed and studied in-depth in order to understand the background of event occurring.

3. Results and discussion
Soil conservation is the placement of a plot of land onto the way of using corresponding to the soil’s ability and an attempt of treating it according to the conditions required in order to prevent damage from occurring. Conservation attempt aims (1) to prevent soil damage by erosion; (2) to improve damaged soil, and (3) to improve soil productivity in order to be used everlastingly (Arsyad, 2009). Apart from increasing farmers' yields, conservation is also very important in improving the livelihoods of rural families [7].

The attempts taken by farmer communities in Beruk Village in conserving oblique land to avoid landslide include:

3.1. The organization of irrigation
The farmers in Beruk Village have their own way of preventing their farmland from landslide. The ways taken by the farmers are varying dependent on the season. The attempt taken by the farmers is, among others, to arrange or to organize irrigation. Water organization during dry season will be easier than that during rainy season. Rainy season will increase water flow rate existing in the farm land, so
that attention should be paid to water management. Basically, the attempt taken by the farmers to maintain their land is to manage the water existing in the land, in which water should keep flowing and notuddle. Water discharge and irrigation time are important components in an effort to optimize crop production in accordance with the planting location and maintain crop irrigation needs. This is supported by efforts to reduce the use of excess irrigation water, allow vegetation to utilize water stored in the soil profile and reduce salt accumulation in the soil profile [8].

3.2. The construction of water channel
Water channel is one of important elements in irrigation system. Water channel functions to flow water from its source to the farmers’ land. Unavailability of water in the downstream area is usually caused by water channels that do not run smoothly due to soil sediment in the upstream which blocks the flow of water (Figure 1). If this continues, farmers pump water to make it available properly. Natural flowing irrigation water works much better than pumped groundwater. Running water is able to create energy for the associated system by removing and transporting sludge and strengthening the foundation of the bank [9].

3.3. Soil cultivation method
Conservation is carried out through measured soil cultivation by improving the quality of the soil structure so that it has an impact on increasing the resilience of crop production systems [10]. Soil cultivation process is conducted in Beruk Village by means of losing it with manual farming tools such as hoe. The land in Beruk Village is vegetable commodity land; therefore the soil should be made loose in order to be fertile. The farmers in Beruk Village generally cultivate the soil in some stages. In preparing one row, four hoeing processes are needed. In the first stage, the land is cleared up from the weeds existing. In the second stage, water channel is prepared. This second stage also aims to make the soil loose. The next stage is to the fertilizing process. The fertilizer used by the farmers in Beruk Village is usually manure and compost coming from the plant and grass residues existing. The fourth stage is to cover the fertilizer with the loosed soil through forming 120-cm sized row. To certain commodity vegetables, mulch plastic will be added. Land cultivation during dry season is different from that during rainy season. During dry season, the soil will be harder, so that it will take more time to cultivate it. To make it fertile, all of rows will be made loose. Meanwhile, during rainy season, the
soil will be cultivated more easily, but the risk of landslide will increase. To overcome this, the farmers in Beruk Village will cultivate the land (Figure 2) by losing some of soil on the row. The soil loosed is the one located on the upper part of row, while the one on the lower part of row will be left to be intact in order to support the soil above strongly.

Figure 2. How to cultivate the land.

Soil maintenance can be done by using compost under crop rotation in the form of legumes and cereals. Farmers use their cultivated land with crop rotation to increase crop yields without using chemical fertilizers. Crop rotation is used as a vegetation crop that can increase production yields, reduce soil loss, reduce chemical fertilizer costs and increase natural animal feed. The yield from vegetation can be used as animal feed and fuel wood [11].

3.4. The use of mulch plastic
Sustainable land management in the watershed can be done through alternative uses of terraced land which are stabilized with vegetation plants in the form of bund trees. This is done to reduce soil erosion that occurs [12]. In order to reduce and stop the amount of soil loss due to land erosion, the Beruk Village farmers apply the principle of land conservation using vegetative and mechanical methods. Land conservation with the vegetative method is any use of plants or plant debris as a medium for protecting soil from erosion, inhibiting surface runoff and improving soil properties. In addition to using grass, the method of vegetative soil conservation carried out by farmers in Beruk Village is the use of mulch.

Figure 3. Use of mulch.

Mulch is the materials (crop residues, plastics, etc.) that are spread or used to cover the soil surface [13]. Plastic mulch is able to increase plant growth by increasing the yield of production. Plastic mulch has the potential to maintain soil moisture by reducing excess soil salinity (Figure 3). This increases the soil temperature to be more controllable and reduces the electrical conductivity of the soil. In addition, the excess sulfur availability in the soil can be reduced very effectively using plastic mulch [14].

This use of mulch plastic has some advantages: to maintain the structure of soil, to inhibit the weeds growth, and to keep the soil from erosion. The farmers in Beruk Village use mulch as a way of preventing the land from landslide. In addition to be good for the plant, mulch plastic serves as the
inhibitor of rainwater in order not to enter into the soil, so that the condition of soil will remain to be stable. The use of mulch plastic also reduces soil cultivation. If not using mulch plastic, the farmers usually cultivate the soil 4 (four) times in a year. Meanwhile, using mulch plastic, soil cultivation is conducted once in a year. It is conducted by the farmers to reduce cost and indirectly can reduce soil erosion level.

In the attempt of reducing and ceasing the soil loss due to soil erosion, the farmers of Beruk Village apply land conservation principle with vegetative and mechanic methods. Land conservation with vegetative method is each of vegetation and residual plant utilization as a medium to protect land from erosion, to inhibit the surface flow rate, and to improve the characteristics of soil. The method of conserving vegetative land conducted by the farmers of Beruk Village is to use mulch, in addition to using grass. The mulch used by farmers can reduce water respiration. Much water is stored in the soil and therefore minimizes the irrigation conducted. In addition, the use of mulch can reduce the intensity of land cultivation by the farmers before planting. Too frequent land cultivation will make the soil loose, so that it can be eroded and landslide can occur.

The cultivation of slope soil through land cultivation is a conservation method conducted by Beruk Village farmers mechanically. Physical or mechanic method is an action or behavior indicated by the soil in order to reduce the surface water flow, thereby can flow with undamaging strength. Beruk Village farmers, with their knowledge, have understood their conservation principle. It can be accomplished using mechanic method, row organization and drainage. Stating that mulch can control the surface water [15].

3.5. The use of Sprinkler

The cultivation of irrigation water equipped with automatic control system highly affects plant growth, land productivity, and water productivity, and farmer group’s income [16]. The sprinkler irrigation method with the center shaft system provides increased efficiency in water and energy use. The device rotates around the shaft on a circular path and then when the machine moves the watering is carried out. Measurement and monitoring of soil conditions are integrated using a multi-depth sensor [17].

One of technologies that can improve the efficiency and effectiveness of irrigation water is sprinkler irrigation. Sprinkler is the plant irrigation technique like rainwater pouring water onto the plant, it usually turns on automatically (Figure 4). The advantage of sprinkler use is that it is more time-efficient, water-efficient, and reduces soil erosion. About 90% of farmers in Beruk Village have used sprinkler as irrigation method in their land. The use of sprinkler can reduce soil erosion, because irrigation process is in the form of water sprinkling like the rainwater distributed evenly. It enables the water to wet the plant evenly and does not result in soil erosion. The attempt taken to maintain the water source is to plant the vegetations that can store water around the water source. This conserving attempt can be conducted by citizens and Indonesian state forest company.

![Figure 4](image.jpg)

**Figure 4.** Use of sprinklers.

Terracing on slopes with vegetation can reduce soil erosion and promote soil infiltration capacity. Land formed by terracing can be protected through composting and crop rotation systems [18]. Nearly all farming efforts in Beruk Village are conducted on oblique land, or the local people usually called it Pereng. Meanwhile, when it is restudied, the oblique land is very vulnerable to landslide, moreover
during rainy season. In the attempt of minimizing landslide potential existing in agricultural land, the conservation of oblique land area is required.

It is very important to engage and commit to communication between conservation scientists and a variety of stakeholders, including government policy makers, practitioners and local communities. This optimism space can certainly form a balance of Conservation [19]. Coordination and contribution by stakeholders are very important to the successful management of Watershed. The stakeholders are each of individuals, groups, organizations, or institutions that can affect or be affected and have interest in the policies made by individual, group, organization, or institution [20]. The role of stakeholders in Watershed management includes, among others:

3.5.1. Government Policy
The success of government policies depends on the extent to which public stakeholders are involved in biodiversity conservation, environmental management and watershed management. Government policies are usually manifested in the form of las [21]. Karanganyar Regency government appeals to plant perennial vegetations to reduce soil erosion level. The government’s role in this case is considered as important to give socialization and to develop institution to achieve the successful conservation program for Solo Upstream Watershed. The institutions that can conduct Coordination, Integration, Synergy, and Synchronization (KISS) are BKPRD (Regional Space Layout Coordination Agency), BP DAS (Regional Agency for Watershed Management)/Watershed Forum and TKPSDA WS Bengawan Solo (Coordination Team for Water Resource Management for Bengawan Solo River area). A previous study, mentioned that out of the three institutions, TKPSDA is the credible one to conduct Coordination, Integration, Synergy, and Synchronization (KISS) in the management of Solo Upstream Watershed (DAS Solo Hulu) [22]. Some measures need to be taken in watershed management: (1) cross-sectoral integrated management; (2) improving the participation of community; (3) improving extension (education), either qualitatively or quantitatively; (4) reinforcing the institution; (5) giving incentives to farmers in Upstream Watershed [23].

3.5.2. Social Group
Human being can be said as social group when fulfilling the following requirement: (1) each member of group should realize that they are some of corresponding group; (2) there are reciprocity between one member and another; (3) there is similarity in such things as fate, interest, objective, political ideology; (4) it is structured, and has norm, and behavioral pattern [24]. Local groups have the strongest position in protecting the environmental conditions of an area. Communities tend to manage land holistically, balancing social, economic and environmental impacts for sustainability. Plant preservation is needed to prevent land degradation. Local groups need clear laws to protect land from exploiting outsiders [25].

Local communities are needed for the continuity of the conservation of nature and wildlife resources in certain contexts. The community is not limited to customs, rituals, regulations, but human interaction in making conservation decisions [26]. There is a social group established deliberately to invite the local people to maintain environment and quality of water available. The Social group includes LMDH (Lembaga Masyarakat Desa Hutan or Forest Village Community Institution) Giri Mulya and Tubing Muslim organizer in Pondok, Pengkok Village. Reforestation activity is conducted by planting vegetations (trees) around the river stream.

3.5.3. Local Leadership
In addition to contributing to the development of organization, leadership also affects organization innovation. Innovation through creativity is important factor to the success and the competitive advantage of organization [27]. Leaders have a responsibility to give influence to those around them in taking advantage of the opportunities given to achieve change [28]. There are some individuals with strong position and influence in the environment of Beruk Village, Jatiyoso Sub District. The community figures are, generally, the leaders existing in Beruk Village, including Head of Village
(Pak Lurah), Head of Hamlet (Pak Kadus) and Head of Neighborhood Association (Pak RT). They are usually considered as important to the community and close to public interest. Even the former Head of Beruk Village still plays important role within the society.

4. Conclusion
The conclusion to be drawn is that the people in Beruk Village located in Solo Upstream Watershed area cultivate one-season plant such as vegetables in their farmland. Conservation attempt taken includes organizing organization, constructing water channel, cultivating the soil correctly, using mulch plastic, and using sprinkler. The participation of stakeholders in the attempt of coordinating Watershed conservation is very important. Socialization or training conducted by PPL (Agricultural Extension Officer) and corresponding service office are very desirable to maintain the natural balance. The participation of various parties is very much needed in preserving the environment and protecting water sources in order to reduce the impact of climate change.

References
[1] Alviya I, Salminah M, Arifanti V B, Maryani R, dan Syahadat E 2012 Persepsi para pemangku kepentingan terhadap pengelolaan lanskap hutan di daerah aliran sungai Tulang Bawang J. Penelitian Sosial Dan Ekonomi Kehutanan 9 171–184
[2] Basuki T M, Wijaya W W, dan Wahyuningrum N 2016 Spatial distribution of land susceptibility to degradation and recommendation for its improvement: a case study in the upper Solo Sub-Watershed J. of Degraded and Mining Lands Management 4 689
[3] Supangat A B, Indrawati D R, Wahyuningrum N, Purwanto P, dan Donie S 2020 Membangun proses perencanaan pengelolaan daerah aliran sungai mikro secara partisipatif: sebuah pembelajaran (developing a participatory planning process of micro-watershed management: a lesson learned) J. Penelitian Pengelolaan Daerah Aliran Sungai (J. of Watershed Management Research) 4 17–36
[4] Ohno T, Tanaka T, and Sakagami M 2010 Does social capital encourage participatory watershed management? An analysis using survey data from the Yodo River watershed Society and Natural Resources 23 303–21
[5] Quinn C H, Fraser E D G, Hubacek K, and Reed M S 2010 Property rights in UK uplands and the implications for policy and management Ecological Economics 69 1355–63
[6] Lastiantoro C Y dan Cahyono S A 2015 Analisis Peran Para Pihak dalam Pengelolaan Daerah Aliran Sungai Bengawan Solo J. Analisis Kebijakan Kehutanan 12 203–12
[7] Karidjo B Y Wang Z Boubacar Y dan Wei C 2018 Factors influencing farmers’ Adoption of Soil and Water Control Technology (SWCT) in Keita valley, a semi-arid Area of Niger Sustainability (Switzerland) 10 2–13
[8] Esthete D G, Sinshaw B G, dan Legese K G 2020 Critical review on improving irrigation water use efficiency: advances, challenges, and opportunities in the Ethiopia context Water-Energy Nexus 3 143–154
[9] Siyal A W, Gerbens-Leenes P W, and Nonhebel S 2021 Energy and carbon footprints for irrigation water in the lower Indus basin in Pakistan, comparing water supply by gravity fed networks and groundwater pumping J. of Cleaner Production 286
[10] Singh D, Mishra A K, Patra S, Mariappan S and Singh N 2021 Near-saturated soil hydraulic conductivity and pore characteristics as influenced by conventional and conservation tillage practices in North-West Himalayan region, India Int. Soil and Water Conservation Research
[11] Debie E 2016 Integrated Soil Management Approach and its Socio-Ecological Implications in Goncha Woreda, North-Western Highlands of Ethiopia. (Ethiopia: Addis Ababa University)
[12] Debie E 2021 Smallholder Farmers’ Decisions to the Combined Use of Soil Conservation Practices in Tiwa Watershed, Northwest Highlands of Ethiopia (Ethiopia: Addis Ababa University)

[13] Subagyono K, Haryati U, dan Tala’ohu S H 2004 Teknologi konservasi air pada pertanian lahan kering dalam: Kurnia U, Rachman A, Dariah A (Eds.) Teknologi konservasi tanah pada lahan kering berlereng Puslitbang Tanah dan Agroklimat, Badan Litbangtan 151–188

[14] Haque M A, Jahiruddin M, and Clarke D 2018 Effect of plastic mulch on crop yield and land degradation in south coastal saline soils of Bangladesh Int. Soil and Water Conservation Research 6 317–324

[15] Subagyono K, Haryati U, dan Tala’ohu S H 2004 Teknologi konservasi air pada pertanian lahan kering dalam: Kurnia U, Rachman A, Dariah A (Eds.) Teknologi konservasi tanah pada lahan kering berlereng Puslitbang Tanah dan Agroklimat, Badan Litbangtan 151–188

[16] Sirait S, dan Maryati S 2019 Sistem kontrol irigasi sprinkler otomatis bertenaga surya surya di kelompok tani Kecamatan Meureubo Kabupaten Aceh Barat J. Irrigasi 13 55–66

[17] Abrishambaf O, Faria P, Gomes L, & Vale Z 2020. Agricultural irrigation scheduling for a crop management system considering water and energy use optimization Energy Reports 6 133-39

[18] Morgan R P C 2005 Soil erosion & conservation J. of Chemical Information and Modeling

[19] Rose D C, Amano T, González-Varo J P, Mukherjee N, Robertson R J, Simmons B I, Wauchope H S, and Sutherland W J 2019 Calling for a new agenda for conservation science to create evidence-informed policy Biological Conservation 238 1–8

[20] Puspitojati T, Darusman D, Tarumingkeng R C, Purnama B 2012 Pemangku kepentingan yang perlu diberdayakan dalam pengelolaan hutan produksi: Studi kasus di desa pemangku hutan Bogor J. Analisis Kebijakan Kehutanan 9 190–204

[21] Wang F, Mu X, Li R, Fleskens L, Stringer L C, and Ritsema C J 2015 Co-evolution of soil and water conservation policy and human-environment linkages in the Yellow River Basin since 1949 Science of the Total Environment 508 166–177

[22] Giyarsih S R 2010 Pemetaan kelembagaan dalam kajian lingkungan hidup strategis DAS Bengawan Solo hulu J Sains & Teknologi Lingkungan 2 90–9

[23] Nugroho S P 2011 Pergeseran kebijakan dan paradigma baru dalam pengelolaan daerah aliran sungai di Indonesia J Teknologi Lingkungan 4

[24] Syarbaini S 2009 Dasar-Dasar Sosiologi (Yogyakarta: Graha Ilmu)

[25] Ounvichit T and Yoddumnern-Attig B 2018 Community dialogues on the probabilities of community-based mangrove institution Kasetsart J. of Social Sciences 39 365–73

[26] Mavhura E and Mushure S 2019 Forest and wildlife resource-conservation efforts based on indigenous knowledge: The case of Nharira community in Chikomba district, Zimbabwe Forest Policy and Economics 105 83–90

[27] Hsiao H C and Chang J C 2011 The role of organizational learning in transformational leadership and organizational innovation Asia Pacific Education Review 12 621

[28] Uworwabayeho A, Flink I, Nyirahabimana A, Peerera J, Muhire I, and Gasozi A N 2020 Developing the capacity of education local leaders for sustaining professional learning communities in Rwanda Social Sciences & Humanities Open 2 1–9

Acknowledgments
The research team would like to thank the Sebelas Maret University Research and Community Service Institute for providing PNPB grants through Letter of Agreement No. 453 / UN27.21 / KP / 2020. We would like to convey our gratitude to the farmers in Beruk Village, Jatiyoso District, Karanganyar Regency who have establish cooperative relationships so that research activities can run well.