Increasing Productivity and Environmental Conservation of Dryland Farming in Bali Island with Three Strata Forage System

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Introduction

Bali is one of the small island bordering the Wallace line, which is separating the flora and fauna in Asian and Australian continent; With 563,286 ha land area 63.5% is in the form of agriculture, 22.3% natural forest, 5.9% housing, 5.9% critical land and 2.4% in other forms. Of the 63.5% agricultural land, 17.3% is rice field, 20.1% is dryland food crop and 26.1% is plantation crop. Agriculture products for export/inter island commodity is Bali cattle, Bali pig, coconut, clove, vanilla and "salak". Rice, corn, soybean and cassava are mainly used for domestic consumptions.

Eventhough water source from rainfall, river, lake and ground water are adequate, its uneven distribution causing 46.2% of the agricultural land in the form of dryland farming area and only 17.3% in the form of wet land farming area. Apart from smallholder farm, increasing population in the past 5 years, that causing every year 3,425 ha agricultural land shifted into housing, added constraints to the agriculture production. In smallholder farm, food crop is the main production, while livestock keeping is a side-line production, so that no land is allocated specifically to grow livestock feed. Too heavy tethered grazing, unjustified lopping of the shrub and tree for fodder and firewood increased the land degradability.

Using the new variety of food crop and plantation crop, using new breeds and artificial insemination for livestock are some of the GO and NGO efforts to increase the agricultural production.

This paper discribed the 17 years research and development of Three Strata Forage System (TSFS) that could increase the land productivity and environmental sustainability of dry land farming in Bali, Indonesia.

Description of TSFS

TSFS consisted of systematic planting and harvesting grass, ground legume, fodder shrub and tree so that ruminant feed are available all year around as standing green. The rational is that ruminant feed would be supplied mainly by the first stratum (grass and ground legume) during the wet season, the second stratum (shrub legume) during the early dry season and third stratum (fodder tree) during the late dry season (Fig. 1). Ground and shrub legumes are included in the TSFS to increase soil fertility through the root nodule contribution of the legume species and to increase the nutritive value of ruminant diet through the inclusion of protein-rich legume forage.

One plot of TSFS consisted of 0.25 ha land divided into 0.16 ha core area, 0.09 ha peripheral area and 200 m circumference area (Fig. 2). The core area in the centre of the plot is planted with food crop or plantation crop; the peripheral area blanketing the core area is planted with improved grass and ground legume is designated as first stratum; the circumference are bordering the peripheral area is planted with fodder tree at 5 m spacing is designated as third stratum; and in between the 2 fodder trees planted with shrub.
legume at 10 cm spacing is designated as second stratum. One plot of TSFS, therefore, consisted of 0.09 ha mixed pasture, 2000 shrub legumes and 42 fodder trees. The traditional system (NTFS) consisted of 0.5 ha land divided into 0.25 ha arable land for food crop and 0.25 ha fallow land for tethered grazing and scattered native grass, shrub legume and fodder trees are used as fence border. The plant tested in the first stratum is improved grass *Cenchrus ciliaris* cv. Gayndah, *Panicum maximum* cv. Trichoglume, and *Urochloa mosambicensis* cv. Common, improved ground legume *Stylosanthes hamata* cv. Verano, *Stylosanthes scabra* cv. Seca and *Centrocoma pubescens*. In the second stratum the shrub legume tested is *Leucaena leucocephala*, *Gliricidia sepium* and *Acasia villosa* and in the third stratum the fodder tree tested is *ficus poacelli*, *Lannea coromandilica*, *Hibiscus tilleacens* and *Erythrina variagata*. The mode TSFS application is integration with food crop or plantation crop and livestock, so that better control of TSFS

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*Figure 1. Concept of feeding all year round.*

*Figure 2. Location of the core, peripheral and circumference area of the TSFS.*
because farmer go to the field every day to look after
the food crop; the food crop is not disturbed because
fenced by the TSFS; ruminant is not tethered grazed
because TSFS supplied with cut and carry green
feed; soil fertility is not reduced because of the dung
manure application and root nodule decomposition
of legume plant; food crop could cover the daily
farmer need, while livestock could cover the urgent
farmer need.

Land Productivity of TSFS

Food crop (corn, soybean and cassava) yield
per plot reduced 43% because 0.09 ha of the land is
allocated for improved mixed pasture. However food
crop production is extended for another year
because of the increased in soil fertility.

Forage yield of the first stratum measured in
terms of improved pasture is 13 times higher and
ground legume is 183 times higher. Fodder yield of
the second stratum measured in terms of shrub
legume is twice higher and fodder yield of third
stratum measured in terms of tree fodder is 3 times
higher. Crude protein content of the TSFS forage is
13% higher, because of the higher crude protein
content of the shrub legume and ground legume
leaves.

Bali steer gained 13% more live weight, 65%
more efficient in feed utilization and 12% faster to
reach export weight (375 kg). Bali cow gained 81%
more live weight, 65% more efficient in feed
utilization, oestrus interval is 31% faster and oestrus
frequency is 69% more often; calf birth weight is 15%
higher and calf weaning weight is 23% higher. Egg
production of native hen is 56% higher and egg
fertility is 22% higher, because the more vitamin and
mineral from the green forage, more plant protein
from the plant seed and more animal protein from
the termite.

One plot of TSFS could carry one steer of 375
kg live weight or one cow and calf up to weaning
weight or six goat of 60 kg live weight each and each
with 12 native hens or 24 cockerell. During the wet
season the stocking rate increased 45% and during
the dry season the stocking rate increased 30%,
while the carrying capacity increased 52%.

Socio-economic of TSFS

Firewood from the second stratum consisted of
Glicidia branch is 112 time higher and from Leucaena
branch is 29 times higher; while firewood from the
third stratum consisted of branch of Ficus, Lannea
and Hibiscus is 75, 163 and 271 times higher,
respectively.

Time spent to care for the TSFS livestock is 16%
less, so that such extra time can be used for social
activity.

Farmer income is 38% higher, while farmer income
is 29% higher. TSFS farmer spends 8.2% more money
to buy protein-rich food and spent 5.5% less money
to buy carbohydate-rich food.

Because of the firewood supply and stall-feeding
of the livestock, the involvement of house wife and
children in the farms are higher and opportunity of
the husband to do off-farm job is higher.

Environmental Conservation of TSFS

Soil run-off decreased 51% because the gravel
movement is reduced by the shrub and tree, soil
movement is reduced by the grass and ground
legume, rainfall velocity is reduced by the plant
canopy, while the wind velocity is reduced by the
shrub and tree fence. Soil fertility measured in terms
of organic matter is 22% higher, total salt is 33%
higher and total nitrogen is 78% higher.

Wood in the forest will not be cut by the farmer
because their firewood requirement is satisfied by
branch of the TSFS shrub and tree lopped regularly
and by pollarded stem of the shrub and tree
depollarded every 3 - 4 years.

Accumulation of leaf and root debris increased
the humus and moisture content of the soil, which
created favourable enviromental condition for the
termite and earth worm. Green canopy of the shrub
and tree reduced the temperature and wind, which
created favourable environment for the snail and
butterfly. Flower of grass, ground legume, shrub
and tree become source of pollen and nectar for the
honey bee. Shrub legume and fodder tree lopped
every 2 months during the 4 months wet season and
every 4 months during the 8 months dry season;
kept the leaves green all year around as standing
green. Two TSFS established side by side forming a
green alley, which is favourable for tracking.

Major Constraints and Possible Solution of TSFS

Jumping plea attack to *Leucaena leucocephala* decreased fodder yield for sometimes. Replacing with *Acacia vilosa* could recover the forage yield due to Leucaena damaged.

Black aphid attack to *Gliricidia sepium* decreased the fodder yield during the dry season. Replacing with Retalhuleu provenance of *G. sepium* could recover the fodder yield due to Gliricidia damage.

Starting one plot of TSFS is quite expensive to smallholder farmer. The TSFS demonstration plot started by GO or NGO will become source of planting material and livestock for the smallholder farmers in that area.

The long terms effect of TSFS on the reproductive performance of the goat is not yet researched. Long terms research grant is needed.

Mechanism of Technology Transfer of TSFS

Some of the specific activities involved consisted consultation with local authority so that the TSFS is in line with the Government policy; formation of farmer group and demostration plot so that the farmer can see the process and the outcome of TSFS; anticipate the custom and tradition that could ease the TSFS technology transfer; academic team to get scientific data to solve TSFS problem, while development team to solve the farmer problem; top-down approach is for the research, while bottom-up approach is for the development of TSFS.

Human Resources from TSFS

In the past 16 years, 74 Bachelor scription, 7 Master thesis and 3 Ph.D. dissertation have been completed using the TSFS data. TSFS has become one of the subject in the undergraduate curriculum of Faculty of Animal Husbandry, and also become one of the subject in the postgraduate curriculum of the Faculty of Agriculture, Udayana University.

Prospect of TSFS

TSFS supported the GO and NGO programme for greening campaign (i.e. 2000 shrub legume and 42 fodder tree in each 0.25 ha land), reforestation (i.e. supplying firewood from branch of 2000 shrub legume and 42 fodder trees in each 0.25 ha land),
social safety-net (i.e. funding to develop one TSFS demonstration plot for each member of 20-25 farmer in one farmer group), added value from agribusiness (i.e. fattened cattle for canning, native chicken for specially roasted chicken) and added value from agrotourism (i.e. green alley for cross-country, standing green for picnic and camping). TSFS has been developed in East Java, island of Nusa Penida, East Sumba, Sumbawa and Alor for renovation of the degraded and critical land.

TSFS is sustainable because it offer simple technology to manage plant and livestock, to reduce soil erosion and land degradation; the technology is appropriate because it used local resource and it could satisfy the technical, biological and socio-economic needs of the small holder farmers; and the technology can easily be adopted and developed.

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Reference

1. Anonymous 1995 Master plan of development of Bali province up to Year 2010 (In Indonesian).

質疑応答

質問者1: The usefulness of this system, you mention several point. Among them, one is a Three Strata Forage System protect soil erosion. But this system is taken, undertaken in the dry land area. Do you think this dry land area soil erosion still occur?

Nitis: Thank you very much. You know during the we mention dry land area, it mean 4 months wet season, 8 months dry season.