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Rethinking erosion on Java: a reaction

J. DE GRAAFF[1] & K.F.WIERSUM[2]

[1] Department of Irrigation and Soil and Water Conservation, Wageningen Agricultural University, Nieuwe Kanaal 11, NL 6709 PA Wageningen, Netherlands
[2] Department of Forestry, Wageningen Agricultural University P.O. Box 342, NL 6700 AH Wageningen, Netherlands

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Abstract

In a recent article (Diemont et al., 1991) about erosion on Java, it has been postulated that low inputs, not surface erosion, is the main cause of low productivity of upland food crops on this island. In this article it is argued that this hypothesis is too simple. An analysis of empirical field data about the effect of erosion on crop productivity indicates that the effects of erosion and agronomic inputs are confounded. Erosion causes farmers to apply low inputs because only limited returns can be expected on eroded lands. The relations between erosion and crop productivity are site specific; the extent and quality of conservation measures and intensity of agronomic inputs varies per soil type.

Keywords: soil conservation, cropping inputs, crop productivity

Introduction

In many countries soil erosion is considered as one of the major forms of environmental degradation. An example of a tropical region where soil erosion has received considerable attention is the Indonesian island of Java (Soemarwoto, 1974; Wiersum, 1980; Repetto, 1986). Already at the end of the 19th century the need to control erosion was noted and in the 1930s efforts were already undertaken to stimulate farmers to adopt erosion control measures (Joosten, 1941; Schuitemakers, 1949). These efforts were mostly discontinued during the politically unstable period of the 1940s and the early years of independence. But after the city of Solo in Central Java was seriously flooded in 1966, the Indonesian government focused attention again on the need for soil and water conservation. In 1969 a programme for erosion control was incorporated in the first Five Year Development Plan (PELITA I); this programme included 33 pilot projects in 12 different provinces. Since that time, increasing efforts have been devoted to watershed management in Indonesia. From 1970 onwards various donors such as FAO, USAID and the Netherlands government assisted in carrying out major pilot projects for watershed management in different parts of Java. A major stimulus was also provided in 1975, when the Indonesian government decided to include soil conservation activities in the so-called INPRES programme, a decentralized development programme implemented at district level (Pickering, 1979).

The Indonesian government has recognized the multi-facetted nature of erosion control measures within the framework of watershed concerns and not less than seven ministeries/agencies have been involved in watershed management efforts. For the planning and coordination of these activities in each important watershed a Watershed Management Planning Bureau was established. The most influential agency in all these programmes has been the Directorate General for Reforestation and Land Rehabilitation of the Ministry of Forestry. This agency has in particular promoted bench terracing on private farmlands, the construction of checkdams in upstream rivers and large gullies, and reforestation of denuded state forest lands. In the period 1976-1986 the investments of the Indonesian INPRES programme for soil conservation on privately owned cropping lands amounted to US$ 166 million. These investments are large in comparison to the government investments in reforestation on the state forest lands and also in relation to the commitments of foreign donor agencies to watershed management, which in 1987 amounted to US$ 50 million (World Bank, 1988).

As a result of all these efforts much progress has been made in respect to soil and water conservation in the uplands of Java. Not only has the area with established soil and water conservation practices increased considerably, but also much new information has been collected from which a better understanding about the nature and importance of the erosion process on Java has emerged. For instance, in a recent article in this journal Diemont et al. (1991) indicated, that in the past attention has been too exclusively focused on surface erosion with other forms of erosion being neglected (see also Rijsdijk & Bruynzeel, 1990). These authors also hypothesize that low agricultural inputs rather than surface erosion is the main cause of low productivity of upland crops on Java. Their article illustrates the importance to make a distinction between various forms of erosion with their effects both on-site and off-site. Some erosion control measures primarily aim at improving crop productivity by restoring soil productivity, while other measures have as main objective to reduce all erosion sources in order to limit downstream damages. In this article we will deal only with the relation between erosion and on-site effects. We will specifically address the hypothesis of Diemont et al. (1991) about the influences of surface erosion and agronomic inputs on crop productivity.

Relations between surface erosion, agronomic inputs and crop productivity

The hypothesis of Diemont et al.

From the article of Diemont et al. (1991) it is not entirely clear whether their hypothesis about the relative effects of erosion and agronomic inputs on crop productivity refers to historic or present conditions. The authors state that at present most upland crop fields are terraced. This statement might imply that their hypothesis relates to present conditions with many soil conservation practices having been established, but with soil productivity still being low. But their hypothesis is supported by historic data indicating a small positive change in productivity of several upland crops during the last decade, which indicates that their argumentation is based on historic trends. Indeed, yields of upland crops have increased during the last decade on Java; these increases were 4.3%, 4.7% and 2.8% per year for upland rice, maize and cassave, respectively (Roche, 1987 in World Bank, 1988). But in the same period average fertilizer inputs rose in the case of maize from 38 kg ha^{-1} to nearly 106 kg ha^{-1}, and for cassave from 8 kg ha^{-1} to more than 16 kg ha^{-1}. Also, the use of improved varieties, especially of maize (Arjuna and Hybrid varieties) has been rising. For instance, an agroeconomic survey in East Java indicated that in volcanic areas and areas with sedimentary soils respectively 61% and 48% of farmers grew such improved varieties (De Graaff, 1989). Finally, as discussed above, also many measures to control surface erosion were established during the last decade. Although statistical data on the rate of adoption and the effectiveness of these measures are lacking, it is generally agreed that at present around 60 – 80% of all upland cropfields have been terraced in one way or another (De Graaff & Dwiwarsito, 1990; Diemont et al., 1991).

The data on the increased crop productivity are interpreted by Diemont et al. (1991) as illustrating that a major decrease in soil productivity as a result of erosion as assumed by Magrath & Arens (1987) has yet to be verified. The authors admit that the observed increase in agricultural productivity might have been higher without surface erosion. Then they argue that the data indicate that surface erosion at least does not hamper agricultural productivity to a degree that any increase of inputs is frustrated, and that proof to that effect has yet to be produced. Thus, although Diemont et al. (1991) admit that the effects of surface erosion and agronomic inputs on crop productivity may be confounded, they state that there is no empirical evidence about the relative effects of both effects on crop productivity. Consequently, they postulate on basis of the aggregated data on crop productivity that low agricultural inputs rather than surface erosion is the main cause of low productivity of upland crops in Java.

Empirical data

The statement of Diemont et al. (1991) that no data exist to verify the effect of surface erosion on crop productivity on Java is not entirely true. There have been published some studies about the effects of erosion and erosion control measures on Java (Gauchon, 1976; Harper, 1988; De Graaff & Dwiwarsito, 1990; see also Barbier, 1990) which indicate that surface erosion does negatively affect crop productivity. One of the first detailed studies on the effect of erosion on crop productivity on Java was carried out in Central Java in the beginning of the 1970s (Gauchon, 1976). On the basis of detailed crop input and output studies on soils with different degrees of erosion, the average costs and yields on moderately and severely eroded volcanic soils were compared (Table 1). On the severely eroded lands overall crop yields were about 40% lower than on the moderately eroded lands. Also a shift from high-valued crops with relatively high requirements in respect to soil fertility (soy-

Table 1. Average inputs and outputs per hectare on old volcanic soils with different degrees of erosion in Central Java (Gauchon, 1976).

	Moderately eroded[a]	Severely eroded[b]
Inputs		
labour total (man-days)	383	147
labour hired (man-days)	94	4
planting material (kg)	49	13
fertilizers (kg)	84	4
compost (1000 kg)	2	1.1
Outputs[c]		
dryland rice (kg)	325	40
maize (kg)	15	1.5
cassava (kg)	1300	650
groundnuts & soybean (kg)	400	62

[a] Moderately eroded: A-horizon entirely eroded, remaining B-horizon is more than 75 cm deep. [b] Severely eroded: Remaining B-horizon is less than 25 cm deep. [c] Outputs of mixed cropping systems

bean and groundnut) to less soil-demanding crops with lower value (cassava) took place. On very eroded lands with only the C horizon remaining, only cassava was still being produced with average yields of 400 kg ha^{-1}. This decrease in crop production is not only due to the loss of soil fertility caused by erosion, but also due to the lower inputs being used on the eroded lands. Obviously, farmers do not want to invest much inputs in crop production on eroded lands, where only limited returns can be expected. Low yields are thus related to the interlinked aspects of erosion and low inputs. Also in a sample survey of rained lands in East Java a clear negative relation between soil depth (reflecting past erosion) and crop yields and net production values was found (Table 2).

The interlinked effects of erosion, inputs and crop productivity is also illustrated by the conclusion of Roche (Nibbering, 1991) that the increase of fertilizer use on the hillsides of the Gunung Sewu region in the period 1979 – 1983 did produce only

Table 2. Soil depth and crop production on different soil types in East Java (De Graaff & Dwiwarsito, 1990)

Soil depth (A & B horizon) (cm)	Lowland mediterranean soils (Alfisols)		Lowland sedimentary soils (mainly Lithosols)	
	yield of maize (kg ha^{-1})	net income[a] (Rp 1000 ha^{-1})	yield of maize (kg ha^{-1})	net income[a] (Rp 1000 ha^{-1})
< 50	445	250	282	140
51 – 75	887	477	526	224
76 – 100	1081	477	848	402
> 100	1059	557	520	403

[a] Plots mainly planted with maize, occasionally mixed with cassave and other crops; net income relates to all crops

a modest increase in output, because of the constraint imposed by soil erosion. Moreover, experiences from the Upper Solo Project indicated, that increasing agronomic inputs without erosion control measures may temporarily increase crop yields, but they do normally not stop erosion (FAO, 1976). Increased agronomic inputs without adequate soil conservation measures may thus temporarily mask the effect of surface erosion, but it does not prevent the long-term effect of erosion on decreasing soil productivity. On the other hand, erosion control measures without increased agronomic inputs do not increase crop productivity, but such measures are a prerequisite for further agricultural intensification.

There seem to be two important reasons why such further intensification has not yet taken place on Java. In the first place it should be noted, that the effect of erosion control measures depends on their quality and proper maintenance and not on their mere presence. Several indications do exist that the quality of the erosion control measures on Java should be further improved (Carson, 1987; Harper, 1988). In the second place many watershed efforts have concentrated on terracing activities and neglected the importance of agronomic practices (Harper, 1988) thus limiting the effects of these measures. Sometimes, especially on the more fertile soils, increases in inputs readily take place once the initial investments in erosion control have been made. Already in the early 1940s it was observed that terracing of relatively fertile volcanic soils in West Java resulted in higher gifts of compost and animal manure, increased labour inputs and increased cultivation of more demanding and higher yielding crops (Joosten, 1941). But, as also indicated by Diemont et al. (1991), in many areas there is a definite need to give more attention to an agronomic follow-up of soil erosion control measures.

Site specific relations

As indicated by the differential effect of erosion control practices on spontaneous intensification of crop inputs, the relations between erosion, agronomic inputs and crop productivity are soil dependent. There are large differences in susceptibility in erosion between different types of soils. Already in the first part of this century it was found that erosion rates in volcanic areas varied between 0.1 – 1.0 mm yr^{-1} (1.2 – 12 t ha yr^{-1}) and in limestone areas between 1.6 – 5.0 mm yr^{-1} (19 – 60 t ha^{-1} yr^{-1}) (World Bank, 1988). Also crop yields on sedimentary soils are lower than on the more fertile volcanic soils with a similar soil depth (Table 2). The returns of inputs on eroded and intrinsically poor sedimentary soils will therefore be less than on relatively richer (and deeper) volcanic soils with similar erosion rates. This means that investments in erosion control are least renumerative on the most erosion susceptible soils. Consequently, there exist important differences between various soil types in respect to the willingness and ability of farmers to invest in erosion control measures and improved agronomic practices. Already in the 1940s it was observed that on volcanic soils terraces are more readily established than on sedimentary soils (Joosten, 1941); similar data were also obtained in recent surveys in East Java (De Graaff & Dwiwarsito, 1990). The effect of soil type on the application of good land husbandry practices is further illustrated by findings, that the quality of terrace construction was lower on sedimentary soils than on volcanic soils (probably because sedimentary soils are shallower and more variable) (Harper, 1988; Carson, 1987; Schuitemakers, 1949) and the earlier quoted data indicating that the use of improved varieties is more advanced on volcanic soils than on sedimentary soils (De Graaff, 1989). Although surface erosion on volcanic soils is at present reasonably controlled on Java, this is to a much lesser extent the case on these sedimentary soils.

Conclusion

The hypothesis of Diemont et al. (1991) that low inputs, not surface erosion, is the main cause of the low productivity of upland crops on Java is too simple. Empirical data indicate that erosion and low agronomic inputs are closely related to each other. The willingness and ability of farmers to invest in erosion control and improved agronomic practices varies between soil types. On relatively fertile volcanic soils it is financially more attractive to invest in soil conservation activities than on the poorer sedimentary soils. Consequently, the effects of soil erosion and agronomic inputs on crop productivity are confounded as well as site specific; they cannot be understood on the basis of aggregated data as presented by Diemont et al. (1991).

The Indonesian government has been carrying out an active programme of soil conservation since the end of the 1960s. This has resulted in 60 to 80% of all uplands now being terraced. Although further improvements in the quality and maintenance of these structures are still needed, the past efforts have contributed to establishing a good base for agricultural intensification. But, as indicated by Diemont et al (1991) additional measures must be taken to control other forms of erosion than surface erosion and to decrease the high river sediment loads up to an acceptable level.

References

Barbier, E.B., 1990. The farm-level economics of soil conservation: the uplands of Java. *Land Economics* 66:199-211.

Carson, B., 1987. A comparison of soil conservation strategies in four agro-ecological zones in the upland of East Java. KEPAS, Malang, Indonesia, 51 pp.

De Graaff, J., 1989. Agricultural and socio-economic conditions; report on an agro-economic household survey. Screening Study Brantas Watershed, Vol. 8, Konto River Project, Malang, Indonesia, 64 pp.

De Graaff, J. & K. Dwiwarsito, 1990. Economic monitoring and evaluation of Konto River project implementation activities. Project Communication No. 15. Malang, Indonesia, 125 pp.

Diemont, W.H., A.C. Smiet & Nurdin, 1991. Re-thinking erosion on Java. *Netherlands Journal of Agricultural Science* 39:213-224.

FAO, 1976. Termination report Upper Solo Watershed Management and Upland Development project, Indonesia. UNDP/FAO Report AG:
DP/INS/72/006, Rome, Italy, 48 pp.

Gauchon, M.J., 1976. Some aspects of watershed management economics. Field termination Report No.7, Upper Solo Watershed Management and Upland Development project, Solo, Indonesia, 174 pp.

Harper, D.E., 1988. The effectiveness of soil conservation components of the Citanduy II project. Resources Management International, Jakarta, Indonesia, 122 pp.

Joosten, J.H.L., 1941. Development and problems resulting from the work done by the Agricultural

Extension Service in the field of soil conservation in West Java. (In Dutch with English summary). *Landbouw* 17:1063-1080.
Magrath, W. & P.Arens, 1989. The costs of soil erosion on Java; a natural resource accounting approach. Environmental Department Working Paper No. 18. Policy Planning and Research Staff, World Bank, Washington D.C., USA, 40 pp.
Nibbering, J.W.S.M., 1991. Hoeing in the hills; stress and resilience in an upland farming system in Java. Australian National University, Canberra, Australia, 311 pp.
Pickering, A.K., 1979. Soil conservation and rural institutions in Java. *IDS Bulletin* 10 (4):60-66.
Repetto, R., 1986. Soil loss and population pressure on Java. *Ambio* 15(1): 14-18.
Rijsdijk, A. & L.A. Bruynzeel, 1990. Erosion, sediment yield and land-use patterns in the Upper Konto Watershed. Project Communication No.18, Malang, Indonesia, 58 & 150 pp.
Schuitemakers, B., 1949. Measures for the conservation of the soil in the Indonesian agriculture on Java. (In Dutch with English summary). *Landbouw* 21:153-176.
Soemarwoto, O., 1974. The soil erosion problem in Java. In: Structure, functioning and management of ecosystems; Proceedings International Ecological Congress, The Hague, Netherlands. Pudoc, Wageningen, p. 361-364.
Wiersum, K.F., 1980. Erosion, rural development and forests on Java. (In Dutch with English summary). *Landbouwkundig Tijdschrift* 92:338-345.
World Bank, 1988. Indonesian structural adjustment, growth and sustainable development. Country Report No. 7222-IND, Washington D.C., USA.