INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 20, No. 1, p. 37-45, 2022

RESEARCH PAPER OPEN ACCESS

Assessment of Check Dam and Spillways Technologies as soil erosion measures in Rain-Fed Agriculture of Khyber Pakhtunkhwa, Pakistan

Abid Hussain[1], Abdul Hassan[2*], Muhammad Zahidullah Khan[3], Arshad Farooq[2]

[1]*Social Sciences Research Institute, PARC-National Agricultural Research Center, Islamabad*

[2]*PARC-Social Sciences Research Institute, Tarnab-Peshwar, Pakistan*

Key words: Check dams, Spillways, Adoption, Benefit-Cost ratio, Soil Erosion, Mositure Conservation, Rain-fed areas.

http://dx.doi.org/10.12692/ijb/20.1.37-45 Article published on January 04, 2022

Abstract

Soil erosion affects the performance of crops and the livelihood of farming families in rain-fed areas. Technologies like check dams and spillways are effective measures for controlling soil erosion. These technologies are comparatively low in cost and easy to construct than conventional brick masonry structures. The study analyzes cost-benefit, carry outs feasibility assessments and projects the potential impact of these technologies in rain-fed areas of district Dera Ismail Khan of Khyber Pakhtunkhwa province, Pakistan. In the study area, soil erosion is caused by monsoon rains, mainly in the months of July and August. Sampled adopter farmers of these technologies brought one-fourth of their operational land under irrigation with the adoption of these technologies. This has almost doubled the productivity of wheat, enhanced that of chickpea and mustard crops by 66% and 21%, respectively. In the second year of adoption, benefit-cost ratios of check dam and spillways technologies are 5.68 and 7.01 respectively. Adoption of these moisture saving technologies help farmers' to diversify cropping patterns by planting vegetables, fruit and forest plants. Fish farming can further add to economic benefits for the farmers. As per rough estimates of the farmers, these technologies can be adopted on about ten thousand acres in the study area. Farmers in the area are resource-poor and might not afford to adopt these technologies on a large scale. Effective awareness, provision of technical services and ease in access to finances can result in large-scale adoption of these technologies.

* **Corresponding Author:** Abdul Hassan ✉ ahassan7796@gmail.com

Introduction

Soil erosion is a prime geographical land degradation event that affects worldwide agriculture (Leh *et al.*, 2013) due to its serious influence on soil fertility along with on productivity, results in a massive loss in crop production (Munodawafa, 2012). Gullies are the worst soil erosion forms that might be considered as an enlargement of watershed drainage system up into the landscape (USDA, 2021). Gullies are defined as small channels or valleys formed due to cutting action of concentrated as well as intermittent runoff during and immediately following heavy rains (Soil Science Society of America, 2008).

It adversely affects the economy through a reduction in agricultural productivity, decreasing farmland value and multiplying the cost of making and maintaining rural infrastructure (USDA, 2021). Gully plugging is a small earthen dam that might be constructed at one or more sites along the gully or vegetation in the areas between the structures (USDA, 2021). Check dams might be used for controlling gully erosion (Lenzi, 2002) that trap the eroded sediments, stabilize channels stream, slope reduction and prevent soil loss in badland areas (Yano, 1968; Zhang *et al.*, 1988; Singh *et al.*, 2002; Shit *et al.*, 2013).

In Pakistan, deforestation, overgrazing, urbanization, low organic matter, improper tillage practices, leaving the land fallow, competing land uses, small and fragmented land holdings, and poverty have accelerated soil erosion. Soil erosion affected 20 percent of the total geographical area (almost 16 million hectares) of the country. Out of this 11 million hectare area is affected by water erosion (about 70%) and more than half of the land (55%) is affected by gully erosion in rain-fed areas of the country. High-intensity rainfalls, steep slopes and erodible soils without adequate protection have led to extensive soil erosion and the consequences are devastating.

They include loss of fertile soil, loss of vegetation, reservoir depletion by sedimentation and eutrophication and contamination of surface and groundwater (Ashraf *et al.*, 2012).

In Pakistan, rain-fed areas are ignored as an investment is mainly made in the canal irrigation system. Crops are grown on 12 million hectare land in rainfed areas that constitute 40 percent of the total cultivated area; however, their contribution to total national production is only 10 percent. Reasons behind this are low and erratic rainfall that affects crops growth at critical stages, soil erosion and loss of top fertile layer, injudicious use of water and land resources and defective or low level of information about science-based modern agricultural methods (Hassan *et al.*, 2015).

Despite this huge soil loss and its consequences to agricultural lands and the terrestrial environment, very little work has been done in Pakistan to address the issue. Conventionally, brick masonry structures were constructed by public departments. These structures were costly and most of them were damaged due to floods, rodent holes, etc., and are were unrepairable. The International Center for Agricultural Research in the Dry Areas (ICARDA) launched the project in Pakistan, sponsored by the United States Department of Agriculture (USDA), in collaboration with PARC, National Center of Excellence in Geology (NCEG)—the University of Peshawar along with other national and international institutions. The prime objective is "to introduce and promote the adaptation of optimal and integrated water and land management technologies for sustainable increases in agricultural productivity and profitability as well as for reducing land degradation in Pakistan's watersheds". The structures introduced in the project area of Dera Ismail Khan (D. I. Khan) were easy to construct, maintain and 5-10 timeless costly than the conventional brick masonry structures.

Check dams introduced in the area were loose stone, simple structures that can be easily built by local builders (*masons*) based on their local traditional knowledge. It does not require more technical skill know-how, and an experienced local builder with little guidance can construct it. Spillways constructed on Terraces help in disposing of the extra water safely downslope conserves water and soil. Both the technologies are site-specific and were not practical in all fields. Old styles of these technologies already exist in the area; however, NCEG introduced the modified style of these technologies in the area. This study has been conducted with the main objective to assess the economic benefits of these technologies for crop/ fruit farming households in the rainfed area of D. I. Khan district of Khyber Pakhtunkhwa, Pakistan.

Materials and mtheods

Check dam and spillways technologies were promoted in the study area by NCEG in the first stage, while Pakistan Council of Research in Water Resources (PCRWR), Regional Office Peshawar adovocated these in the second stage of the project in Khyber Pakhtunkhwa province of Pakistan. The lists of adopters of these technologies were obtained from the Regional Office of PCRWR, Peshawar. Keeping in view, tough terrain of the area and a limited number of adoptions, thirty adopter farmers of spillways and ten of check dam were randomly surveyed during April 2018. The survey team was comprised of social scientists from Social Sciences Research Institutes, NARC, Islamabad, Tarnab-Peshawar and engineers/ technical field staff from PCRWR sub-office in D. I. Khan. Respondent adopter farmers of Check Dam interviewed for the study were belonged to Gora Ghulam Sadiq and Mouza Rozi Khan Villages of Daraban tehsil of D. I. Khan District. Spillways technologies were mainly adopted in Kulachi tehsil of district D. I. Khan and adopter farmers were belonged to Kulachi, Ghareeb and Gandapur villages.

The data was analyzed through SPSS-22 for descriptive statistics and cost-benefit analysis of these technologies.

Results and discussion

Farmers' characteristics and technology adoption

Demographic characteristics of the sample adopters of the technologies are given in Table 1. Sampled adopter farmers were at in young age with substantial experience in crop farming. The mean age and crop farming experience of adopter farmers were about 44 and 24 years, respectively.

Table 1. Demographic characteristics of farmers.

Characteristics		Check-dam (n=10)	Spill-ways (n=30)	Overall (n=40)
Age (years)		53.5 (23.3)	41.8 (9.1)	44.1 (2.2)
Crop farming experience (years)		36.0 (33.9)	20.6 (11.8)	23.7 (16.7)
Education (years)		3.0 (4.2)	9.0 (6.5)	7.8 (6.4)
Family size (number)		13.0 (9.9)	13.7 (9.7)	13.6 (9.2)
Operational land holding (acre)	Rain-fed	42.2 (2.2)	59.4 (87.6)	56.0 (77.6)
	Irrigated	6.2 (8.8)	21.0 (32.7)	18.1 (29.6)
	Total	48.4 (6.6)	80.4 (76.8)	74.1 (69.1)
Livestock holding (number)		13.0 (5.7)	18.3 (16.8)	17.2 (15.1)
Farm tractors and machinery (percent)				70
Irrigation System (percent)	Check dams and /or spillways			70
	Solar lift pumps & rod kohi system			25
	Runoff/flood water			75

Note: Figures in parenthesis are standard deviations.

Source: Survey data 2018.

They had considerable schooling with, on average, eight educational years. The family size of adopters was quite large with an average of fourteen members due to the prevailing joint family system in the area. Similarly, operational landholding and livestock ownership were large, with a mean of 74 acres and 17 animal numbers per farm household, respectively. Seventy percent of the sample farmers reported having their own tractors and farm machinery. More than three-fifth (70 percent) of the respondents irrigated their crops through check dams and /or spillways. Additionally, respondents also reported that they manage occasional supplemental irrigation to crops through lift pumps or flood water/ rod kohi systems. One-quarter of the sampled farmers reported having irrigation sources (solar lift pumps & rod kohi system) at their farms, while the remaining (75 percent) are solely dependent on runoff/ flood water.

Irrigation System and income

Farming households in the rain-fed study area have very diversified income sources. The agricultural income is generally low due to scanty and erratic rainfall. The average annual rainfall is 249 mm per annum, about half of which (44 percent) happens from July to September (CLIMATE-DATA.ORG, 2019). At sampled farms, crop and livestock collectively shared less than three-quarters of the household income (63.5 percent). Thus, farming families of the study area supplement their income through small enterprises, agricultural service provision and trade, public/private jobs and labour. Small enterprises, agricultural service provision and trade shared 12.8 percent and public/private sector jobs shared 11.6 percent in the total income of sampled farming households. Similarly, labour and remittances collectively shared the remaining 12.1 percent of the total household income of farming households (Table 2).

Table 2. Demographic characteristics of farmers.

Sources	Check-dam (n=10)		Spill-ways (n=30)		Overall (n=40)	
	Mean	%	Mean	%	Mean	%
Crops	218850 (63639)	53	215588 (149535)	43.5	216404 (108852)	45.6
Livestock	34000 (22627)	8.3	101875 (83235)	20.5	84906 (58126)	17.9
Small enterprises, Agri. services & trade	0	0	81250 (229810)	16.4	60938 (146504)	12.8
Government/Private Jobs	0	0	73500 (207889)	14.8	55125 (132529)	11.6
Labour	69000 (72125)	16.8	18750 (53033)	3.8	31313 (49733)	6.6
Remittances	90000 (127279)	21.9	5000 (14142)	1	26250 (36062)	5.5
Total	411850 (256401)	100	495963 (241014)	100	474935 (208132)	100

Note: Figures in parenthesis are standard deviations.

Source: Survey data 2018.

Perceived status of adopting new technologies

The respondents viewed that floods in the area were the sole cause of soil erosion that was mainly crop-up during monsoon season (July and August).

The adopters of check dam technology stated that the check dam was helpful for control of soil erosion, generally made with bricks or blocks, stones and concrete. While, spillways adopting farmers perceived that the technology was effective in reducing soil erosion, followed by retaining walls and establishing vegetation cover.

Sampled farmers reported having awareness about check dam and spillways technologies for the last three-four years. Most of the farmers reported that fellow farmers (50%) and project personnel (40%) made them aware of these technologies while a few farmers (10%) informed input dealers as source of information about these moisture saving technologie. They professed that project personnel are the most effective source of information for them about technologies and declared fellow farmers and input dealers as effective sources of knowledge. All the sampled farmers reported visiting at least one farm of other adopters of the technology in their area.

The mean experience of the farmers about these technologies was two years. Forty percent of the farmers reported obtaining formal training about the technology construction before its adoption.

These training programs were arranged by the Directorate General Soil & Water Conservation Khyber Pakhtunkhwa. Thirty percent of the farmers reported to attend Farmer Field Days organized under the project and also to visit project demonstration sites (Table 3).

Table 3. Perceived status of adopting new technologies.

Awareness about technologies		Unit	Overall (n=40)
		Years	3-4
Source of awareness	Fellow farmers	percent	50
	Project personnel	percent	40
	Input dealers		10
Visit adopter farms		Number	1
Experience of technology adoption		years	2
Formal training		Percent	40
Farmers Field Days attended		Percent	30
Project demonstration site visit		Percent	30
Access to construction material	Own localities	Percent	75
		Kms	3.4
	3-4 locations	Percent	25
		kms	70
Credit obtained		percent	60
		PKR	197500
Contact with technical personnel		Numbers	3

Source: Survey data 2018.

Most of the farmers (75%) reported access to construction material in their own localities. They reported having the availability of construction material at three to four locations, with a mean distance of their farms from markets of 3.4 kilometers, while reaming farmers (25%) reported purchasing construction material from non-local markets of Darazinda and D. I. Khan, with a mean distance of 70 kilometers from their farms. Respondents in the study area have quite good access to credit institutions (ZTBL and Commercial Banks), as 60 percent reported obtaining a loan at least once in the last three years with a mean amount of PKR 1,97,500. Half of the farmers expressed to have sufficient access to technical peoples/ Agricultural Service Providers (ASPs). On average, each farmer have contacts with three technical persons/ASPs. The majority of the respondents (60 percent) argued that the number of technical persons/ASPs in the study area was insufficient for fulfilling farmers' need for technical knowledge and timely assistance (Table 3).

Construction and maintenance costs

The sampled respondents viewed that the check dam could be constructed in about one month time. The average cost of construction of check dams in the study area was PKR 2,60,000. The cost of constructing a storage pond along with irrigation infrastructure in the study area was PKR 1,72,500. Hence, the total average cost of constructing a check dam along with related infrastructure was PKR 4,32,500. Moreover, the construction cost of spillways varied from PKR 8,751 to PKR 4,00,000 per structure depending on the size of the gully, topographical conditions and construction material. Similarly, the number of spillways ranges from one to seven, with a mean of two structures per farm and the time of constructing spillways on sample farms ranges from three to twenty days with a mean of fifteen days. The total average expenditures on constructing spillways per farm in the study area were PKR 2,15,000 (Table 4).

Owing to the socio-economic conditions of local farmers, the adoption cost of these technologies might be considered quite substantial. Hence, the adopter farmers were provided with a 60% subsidy on the construction cost of check dams and spillways. On average, adopters of check dams and spillways technologies shared PKR 1,04,000 and PKR 86,000 in total construction cost per farm, respectively. Repair and maintenance cost for check dams was not reported, as these have strong concrete structures and were recently built. However, spillways are comparatively less costly and require occasional repair. Annual repair and maintenance cost per annum of spillways per farm averaged PKR 11,413. Considering the functional life of these structures, the total annual cost of check dam and spillway technologies with 60% subsidy on the construction of the main structure was PKR 27,650 and 28,613, respectively (Table 4).

Table 4. Construction Cost of Check dams and Spillways.

Cost Items	Check Dams	Spillways
a. Construction cost of main structure	260000	215000
b. Construction cost with 60% subsidy	104000	86000
c. Expected life (years)	10	5
d. Construction cost with 60% subsidy per annum (b/c)	10400	17200
e. Storage pond and irrigation infrastructure	172500	0
f. Storage pond and irrigation infrastructure per annum (e/c)	17250	0
g. Total cost (a+e)	432500	215000
h. Repair and maintenance cost per annum	0	11413
i. Total cost per annum (d+f+g)	27650	28613

Source: Survey data 2018.

Benefits, Profitability and adoption prospects

Adopters of check dam technology reported that the main advantages observed by them are protection of land from soil/water erosion, increase in area under cultivation, water storage and its use for supplemental irrigations to increase crop productivity, diversifying crops by vegetable cultivation and opportunity to bring more land under cultivation. Other benefits are direct irrigation of crops in flood season, plantation of forest trees along the water channel and fish production at farms where ponds have been constructed for water storage.

Similarly, the adopters of spillways technology reported that safety of land from floods and resulting water erosion, the opportunity of the increasing area under crop production, resulting in income increase are the benefits of the technology that convinced them for technology adoption.

Landholding in the study area was generally large in size. The farmers' stated that the construction of check dams added more land of an average of 10.87 acre per farm. All the sampled farmers provided supplemental irrigations to the wheat crop, half of the them irrigated mustard crop and vegetables after the construction of check dams. The average land allocated to wheat and mustard crops at farms was 18.75 and 7.51 acres, respectively. Farmers reported that vegetable production was solely for household consumption, as vegetables were grown on limited land on sampled farms. Water stored in check dams was used for supplemental irrigation that resulted in an increase in the wheat crop production from 4.7 pounds per acre under rain-fed conditions to 9.4 pounds per acre. Similarly, under rain-fed conditions, the production of the mustard crop in the study area was 10.1 pounds per acre that incrased to 16.8 pounds per acre through the application of supplemental irrigations, specifically at critical crop production stages. Crop productivity in the study area is quite low, as chemicals inputs (weedicides, pesticides and fertilizers) are not used. The study showed that check dam technology has high returns with a benefit-cost ratio of 5.68 in the second year of construction and that are expected to be further increase in coming years through increase in livestock productivity and rise in income from sale of forest trees (Table 5).

Similarly, the benefits of constructing spillways in the study area resulted in a command area of 28.71 acres per farm. The allocation of the area to wheat and chickpea crop per farm was 24.6 and 4.1 hectares, respectively. The construction of spillways increases the production of wheat and chickpea crops, through supplemental irrigation by 92 percent and 21 percent, respectively. The adopter farmers of the technology obtained additional income of PKR 2, 00,441 in the year 2017-18 with a benefit-cost ratio of 7.01 (Table 5).

Table 5. Benefits due to additional production.

Crops	Yield (mound/ acre)			Price	Ad. Income
	Normal	Adoption	Additional	PKR/mound	PKR?acre
I. Check Dams					
Wheat	4.7	9.4	4.7	1280	6016
Mustard	10.1	16.8	6.7	680	4556
A. Additional income per farm from wheat crop (additional income per acre x area in acre) = (6016 x 18.75) = 112800					
B. Additional income per farm from mustard crop (additional income per acre x area in acre) = (4556 x 7.51) = 34216					
C. Additional income/benefit per farm from vegetables = 10000					
D. Total additional income per farm (A+B+C) = 157016					
E. Benefit-cost Ratio (D/Total annual cost) = 157016/27650 = 5.68					
II. Spillways					
Wheat crop	7.7	14.8	7.1	1080	7668
Chickpea	5.8	7	1.2	2400	2880
A. Additional income per farm from wheat crop (additional income per acre x area in acre) = (7668 x 24.6) = 188633					
B. Additional income per farm from chickpea crop (additional income per acre x area in acre) = (2880 x 4.1) = 11808					
C. Total additional income per farm (A+B) = 200441					
D. Benefit-cost Ratio (C/Total annual cost) = 200441/28613 = 7.01					

Source: Survey data 2018.

Though, resource availability affects the adoption of technologies like check dams and spillways to a great extent in the context of the socio-economic status of the farmers. However, the farmers of the area are very optimistic about these technologies and all of them reported the continuity in adoption and intention to construct more check dams and spillways at their farms. Respondents expressed their enthusiasm for doubling their area under cultivation through the adoption of these technologies in the near future (two-three years) at their farms. According to farmers' estimates, about 1000 acres more land might be made cultivable by constructing check dams and spillways in just two villages that were surveyed for this study.

Conclusion

Gully plugging and spillways are promising moisture-saving technologies for rain-fed areas that help to control soil erosion. In district D. I. Khan of Khyber Pakhtunkhwa province of Pakistan, adoption of these technologies resulted in an increase in crop productivity of main crops. Moreover, it made it possible for the adopter farmers to increase cropped area and raised crop-livestock diversification options for them. Considering poor natural resource endowment of the area farmers, rapid and extensive adoption of these technologies is possible with the creation of mass awareness among them about benefits of adoption by agricultural extension department through arranging visits of farmers to adopters' farms, provision of effective technical services by soil conservation department to them, and improved access to financial support/ credit supplies by the non-government organization and agriculture/commercial banks. Extension and development programs/ projects can be devised by the public sector for the promotion of these technologies. Similarly, print and electronic media could also be used to raise awareness among farmers about the actual as well as potential socio-economic benefits of the adoption.

Acknowledgments

The authors greatly acknowledge the technical and financial support provided by the USDA for the execution of the project activities in Pakistan. The technical contributions of ICARDA (Head Quarters, Lebanon and Regional Offices, Jordan & Pakistan) are also very much appreciated. Specifically, the contribution of the ICARDA-Pakistan office is highly commendable in making the collaborative efforts of technical, developmental and socio-economic project partners successful. Authors are extremely grateful for the overwhelming support provided by technical as well as developmental partners during field activities, including technical input in designing survey tools and execution of field surveys in far-flung areas of the country.

References

Ashraf M, Bhatti ZA, Zakaullah. 2012. Diagnostic analysis and fine tuning of skimming well design and operational strategies for sustainable groundwater management- Indus basin of Pakistan. International Journal of Irrigation and Drainage **61,** 270-282.
http://dx.doi.org/10.1002/ird.636

Ashraf M. 2015. Promising land and water management practices [A manual]. International Center for Agricultural Research in the Dry Areas (ICARDA), Pakistan.

Ayub A. 2020. Gully plugging spillway is an effective gully rehabilitation measure: A case study of District Gujrat-Pakistan. Big Data In Water Resources Engineering **1(1),** 6-9.
http://doi.org/10.26480/bdwre.01.2020.06.09

CLIMATE-DATA.ORG (2019, April 12) Retrieved from the website
https://en.climate-data.org/asia/pakistan/khyber-pakhtunkhwa/dera-ismail-khan-3494/

Hassan F, Ashraf M, Farooq M. 2015. Rain water harvesting system [Urdu Booklet]. Pakistan Council of Research in Water Resources (PCRWR), Islamabad.

Leh M, Bajwa S, Chaubey I. 2013. Impact of land use change on erosion risk: an integrated remote sensing, geographic information system and modeling methodology. In: Ayub, A. 2020. Gully plugging spillway is an effective gully rehabilitation measure: A case study of District Gujrat-Pakistan. Big Data in Water Resources Engineering **1(1)**, 6-9.
http://doi.org/10.26480/bdwre.01.2020.06.09

Lenzi, MA. 2002. Stream bed stabilization using boulder check dams that mimic step-pool morphology features in Northern Italy. Geomorphology, 45, 243–260. In: Shit PK, Bhunia GS, Maiti R. 2013. Assessing the performance of check dams to control rill-gully erosion: Small catchment scale study. International Journal of Current Research **5(4),** 899-906.

Liu C. 1992. The effectiveness of check dams in controlling upstream channel stability in northeastern Taiwan. Erosion, Debris Flows and Environment in Mountain Regions (Proceedings of the Chengdu Symposium, July 1992). International Association of Hydrological Sciences (IAHS) **209,** 423-428.

Munodawafa A. 2012. The effect of rainfall characteristics and tillage on sheet erosion and maize grain yield in semiarid conditions and granitic sandy soils of Zimbabwe. In: Ayub A. 2020. Gully plugging spillway is an effective gully rehabilitation measure: A case study of District Gujrat-Pakistan. Big Data in Water Resources Engineering **1(1)**, 6-9.
http://doi.org/10.26480/bdwre.01.2020.06.09

Shit PK, Bhunia GS, Maiti R. 2013. Assessing the performance of check dams to control rill-gully erosion: Small catchment scale study. International Journal of Current Research **5(4)**, 899-906.

Singh S, Dubey A. 2002. Gully erosion and management methods and applications (A Field Manual). New Academic Publishers, Delhi. In: Shit PK, Bhunia GS, Maiti R. 2013. Assessing the performance of check dams to control rill-gully erosion: Small catchment scale study. International Journal of Current Research **5(4),** 899-906.

Soil Science Society of America. 2008. Glossary of Soil Science Terms. InSoil Science Glossary Terms Committee. In: Ayub A. 2020. Gully plugging spillway is an effective gully rehabilitation measure: A case study of District Gujrat-Pakistan. Big Data in Water

Resources Engineering **1(1),** 6-9. http://doi.org/10.26480/bdwre.01.2020.06.09

USDA. 2021. Gully Treatment, Chapter 10, National Engineering Handbook, Part 650 Engineering Field Handbook, National Resources Conservation Service. United States Department of Agriculture.

Yano Y. 1968. An investigation report on the sabo works in Taiwan. In: Shit PK, Bhunia GS, Maiti R. 2013. Assessing the performance of check dams to control rill-gully erosion: Small catchment scale study. International Journal of Current Research **5(4),** 899-906.

Zhang HX. 1988. The use of silt trap dams in Xingzi River Basin. In: Shit PK, Bhunia GS, Maiti R. 2013. Assessing the performance of check dams to control rill-gully erosion: Small catchment scale study. International Journal of Current Research **5(4),** 899-906.