Improvement to CARE - CAGES database

CAGES 2
DFID - Research Project R7100

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Contents

1. Aims of this project, based on recommendations from the 1999 Annual Review

- improve the management, structure and utilisation of the database, resulting in better information on project beneficiaries, including the linking of social surveys to technical data

- recommend procedures for data verification in order to improve the reliability of the database and hence the results and conclusions that can be obtained

- make the database easier to understand and more accessible to CAGES staff and other interested parties

- develop the technical knowledge and skills of CAGES staff in data processing, manipulation and presentation

- make recommendations on data that the CAGES staff are required to collect from cage operators in future years to provide the information required by the project while at the same time minimising collection time and effort. This is important considering the proposed expansion of the CAGES project, and the likely increase in staff time devoted to data collection

- make recommendations on the development of closer links between the database manager and field activities, so that observable trends in the data and new ways of analysing data are based on needs and issues in the field

2. The existing data management strategy

2.1. Practical problems with the existing spreadsheet

Initial observations suggested that there is significant scope for improving the standard of data entry to the spreadsheet. In several instances it was apparent that data had been entered incorrectly, often to the adjacent column, an understandable mistake considering the size and layout of the spreadsheet. The headings for the columns of the spreadsheet were in some instances ambiguous and lacked clarity; it is recommended that more thought be given to the layout of spreadsheets where they are employed. Simple steps include expanding column headings and including units for reference. Where codes are being used in place of variables collected in field, it would be useful if the variable to which the code relates was included at the bottom of the page or even on a separate sheet within the spreadsheet. Simple alterations such as this would assist project staff who are not familiar with spreadsheet layout and coding. Providing clearer headings would also mean that rough copies of the data printed directly from the spreadsheet for scrutiny or incorporation in interim project reports would be more easily understood.

2.2. Improving analysis and reporting of information within the existing data management framework

Developing simple data extraction and interrogation procedures using Excel, for common indicators e.g. stocking density, species type, weight at stocking and feed input could contribute significantly to the efficiency with which data is analysed and summarised. Using filters represents an important strategy for extracting appropriate data sub-sets e.g. species, region, household etc.; the use of more powerful formula within the spreadsheet also has the potential to enable data relating to specific variables and ranges within variables to be extracted. Simple statistical techniques such as correlation and regression also have a key role to play in highlighting trends across the extensive data sets being compiled within the CAGES project.

2.3. Problems with data interpretation and reporting during the previous project phase

2.3.1. Depreciation

The assessment of depreciation has emerged as a key factor governing the economic performance of cage aquaculture at the household level. It appears that depreciation has largely been assessed based on the estimates of farmers regarding the working life of the cage and the number of cycles that can be completed in each year. However, it is questionable whether new entrants into cage aquaculture are in a good position to make accurate predictions regarding the durability of cage materials. In addition, the notion that cage aquaculture is conducted in a series of distinct cycles may not fully represent the management practices that are currently employed by participants. The considerable amounts that participants are spending on maintaining their cages appears to indicate that the actual period after which the entire cage will require replacement may be relatively long.

It is recommended that the project staff may be in a better position to make estimates of an appropriate rate of depreciation for the various cage types operated within the project. It would also be reasonable for the project staff to assess the financial returns generated by the cages based on a range of depreciation rates.

2.3.2. Culture cycles

The collection of production data based on consecutive culture cycles throughout the year assists in assessing the various management strategies employed by participants; however, the overall performance of participating households is based on financial returns during a year. It some instances the farmer's estimate of the number of culture cycles possible in a year exceeds that actual number of culture cycles that have been reported. This has resulted in depreciation being under estimated on those production cycles that have been reported. In addition, within the 1998 data set, depreciation was omitted for participants who did not purchase a new cage in 1998; this minor oversight should be corrected when entering data from continuing participants in the future. One possible approach (used in this report) is to use the depreciation rates reported in previous years; alternatively, the depreciation rates estimated by project staff could be used.

2.3.3. Project appraisal

Currently, the performance of households is largely based on the return on investment (ROI) generated by cage aquaculture; however, this approach appears to represent a constraint to assessing the economic performance of cage aquaculture. Introducing an analysis based on a discounted cash flow may better represent the actual economic performance of cage aquaculture in Bangladesh and help to elucidate the level of risk to which participants are exposed, especially if some form of sensitivity analysis was included. The assessment of discounted cash flow may be difficult to achieve using Access; if this approach were to be considered the development of a separate spreadsheet-based module would be the most appropriate strategy. For simplicity it may be better to continue with an assessment of ROI; however, the level of performance achieved should be measured against the guidelines proposed by CARE Bangladesh regarding acceptable rates of return. It would also be interesting to compare the performance of cage aquaculture against other potential livelihood strategies.

2.3.4. General data management

The use of a spreadsheet package for handling data within the CAGES project has restricted the integration of the various data sets that have been collected. An essential component of the CAGES project appears to be the elucidation of key socio-economic factors that have the potential to influence the level of success achieved by participants. However, the comparison of variables from the spreadsheet containing information from the socio-economic baseline survey and production data contained in another extensive spreadsheet would be virtually impossible. Therefore it was recommended that serious consideration be given to developing a basic database that would enable information from the socio-economic baseline survey, production data and information from case studies to be linked.

3. Instigating a database and improving the management and utilisation of data

Although referred to as the CAGES database the data on production and baseline information was being held in extensive Excel spreadsheets. During the initial phase of the project this may have been a viable option; however, as the data set expands during the anticipated rapid expansion phase of CAGES project, then it will become increasingly difficult to manage the data effectively within an Excel framework. It is recommended that the data collected both from production monitoring and future baseline surveys should be held in a dedicated database. During discussions with CAGES staff and members of other project in the ANR Sector regarding their data management systems, two clear approaches presented themselves:

- the first would be for project staff to develop a database from first principals

- the second would be to contract a specialist database developer to produce a package that meets the current requirements of the CAGES project

Other CARE projects such as NOPEST and INTERFISH have contracted external database developers to construct dedicated databases, these are relatively inflexible but provide a friendly user interface and are capable of producing a limited range of outputs with little or no data manipulation by the database manager. Due to the ongoing evolution of the CAGES project and the limited time that the project has to run commissioning the development of a database from an external contractor may not represent the best option. Constructing a basic database from first principals, which can be implemented quickly and meets the immediate demands of the project but still allows scope for development appears to represent a more appropriate solution for data management and analysis within the CAGES project.

During an initial planning phase, staff from the CAGES 2 project and the incumbent database manager considered the relative merits of FoxPro and Access. The general consensus was that adopting Access would allow other CAGES staff to better utilise the database due to the fact that Access is to a large extent menu driven whereas FoxPro relies more on basic programming. Although, Md. Shahroz Anam (TO-ME&S) has a good understanding of basic programming in FoxPro, his aptitude for grasping new concepts suggested that working with Access would not represent a significant problem. In addition, the continued support in database design and management that should be provided by a local trainer will ensure the transition of the database from development to implementation occurs smoothly, irrespective of which package is being used. An additional factor to be considered was the familiarity of the CAGES project staff with Excel and the ease of data transfer between these two packages. Therefore, considering the relative merits of the two database packages, Access appears to represent the best solution to the problems of data management and coordination currently being experienced within the CAGES project.

3.1. Opportunities for improving data interpretation and reporting

Modifications to the framework in which the data collected from the CAGES project is managed will enable data manipulation and analysis to be conducted more efficiently. The ability to select a limited number of data fields in Access and then submit queries regarding specific arguments relating to the data should allow comparisons of performance of numerous variables specific to both the management of the cage and the status and resources of the household. Key management variables relating to the management of the cage would include species, stocking density, size at stocking, feed input, overall investment and time allocated to cage aquaculture. Analysis based on variables relating to the household could include access to water, education, wealth and experience.

The database should also facilitate the comparison of more strategic issues within the CAGES project for example the effectiveness of individual NGOs could be assessed and compared with other NGOs, or a comparison could be made between the performance and management strategies being adopted in different regions. The key component of data interpretation and reporting will be the ability of the database manager to interrogate the data in a flexible manner. The formulation of basic queries using Access has been demonstrated during this assignment; however, it is important that the database manager receives continuing support so that the evolving needs of the project can be met.

3.2. Proposed structure

3.2.1. Integrating different data sets

The major problem with data management within the CAGES project is the lack of integration of different data sets. It is difficult because the manner in which individual households have been identified has relied mainly on participants names (1997) and then in 1998 the same household numbers being assigned by NGOs in different regions which lead to confusion in findings of the 1999 Annual Review.

It is proposed that either each household within the project be assigned a unique household identifier i.e. NGOs in the 6 regions will be allocated HhID numbers between 1-1999, 2000-3999, etc. or the facility in Access of using two fields as a primary key is utilised. The obvious fields to use would be the numbers assigned by NGOs to households in their region and the NGOs code number; however, it will be necessary to ensure that Hh numbers are being used consistently by the NGOs and that the numbers of farmers who dropout are retired. Assigning unique household identifiers, either at the project or regional level, will enable the integration of production data collected from different years with baseline information, reports from case studies and the output from any future initiatives within the CAGES project.

3.2.2. Normalisation

The first step was to transfer the existing data from 1998 Excel to Access. The format of the data from the spreadsheet was then modified in an attempt to normalise the database. Essentially the production data deals with three entities i.e. household, cage and cycle. Therefore, the first task was to divide the information relating to these objects into three separate tables. Within the three tables further normalisation was achieved by removing information on village location and species characteristics to separate look-up tables; these look-up tables also present an opportunity to include extra information such as coordinates for GIS and species specific information e.g. Latin and local name.

3.2.3. Integrity

Business rules can be use to test basic assumptions relating to specific logical statements regarding the data. Appropriate business rules include: harvest date must be after stocking date; stocking date or harvest date must be within current project period; location can only be village in which project works; number of hours work per day can't exceed 24 and codes must relate to coded variables. It is recommended that once the design of the database has been finalised, basic business rules should be introduced to test the validity of the datum being entered. The general integrity i.e. entity and referential integrity, should be tested once the content of the database has been finalised, the testing of integrity is essentially a refining stage rather that a basic design stage. However, within Access the conditions for general integrity are easily defined using the relationships-function. It is recommended that John Bostock, the database consultant from the UK who is contracted to work on this project, test the integrity of the database prior to implementation by staff from the CAGES project.

3.2.4. Linking tables within the CAGES database

As the household is to a large extent the focus of the project it is proposed that the unique household identifier, either at the project or regional level will be used to link the current production data with baseline information and outputs from detailed case studies. The case studies may be more narrative than quantitative therefore it is recommended that hyperlinks are used to link information in the Access database to text documents containing transcripts of the case studies. It is recommended that the text documents be maintained in the same directory as the data file then it should be possible to move the database and document files between computers (John Bostock, *pers*. *comm*.).

With respect to production data and socio-economic baseline information collected during 1997 it is recommended that the relative merits of linking this information with that from the 1998 production cycle and any future data collection is carefully assessed at a strategic level. The time and effort required to link this data successfully with current production data is likely to be considerable; particularly due to the problems regarding household identification outlined in section 3.2.1.

3.3. Data input, analysis and reporting

Transferring the management of data within the CAGES project to Access provides the opportunity to develop a user-friendly interface that is accessible to all project staff. Data input forms should enable data to be entered quickly and with a limited margin for error; the incorporation of basic tests for data integrity will assist in limiting the entry of erroneous datum. It is anticipated that additional technical assistance from John Bostock will enable sound forms to be developed that meet the demands of the project staff.

Due to the fact that the format of the production and baseline surveys are currently under revision and it is not clear exactly what variables will ultimately be required in the final analysis; therefore, preset report forms do not appear to represent the best option for data analysis and reporting. It is recommended that in addition to the basic queries that have been demonstrated and explained to the database manager, other queries are developed that take into account any new variables that may be present in the revised surveys. These might include analysis of the various socio-economic indicators suggested in the 1999 Annual Review.

3.4. Detailed economic analysis and refined statistical tests

Basic queries that have been developed include ones capable of calculating the average cost, profit and ROI for the culture cycles conducted. Using this information it is possible to assess the performance of various management strategies i.e. type of species stocked, stocking density employed, size of seed stocked and investment. In addition, it will be possible to assess performance against a wide range of factors that have the potential to influence management decisions i.e. household status, access to water resources, location or the partner NGO.

However, the development of more complex data analysis techniques e.g. advanced statistical analysis or more refined economic analysis, will probably require selected data from the Access database to be exported to a suitable package capable of supporting the required analysis. The decision which package to use will probably depend on the preference of the individual, Excel provides a suitable environment for conducting more advanced statistical analysis as does SPSS; however, if economic evaluations based on discounted cash flows are to be developed Excel probably represents the best option.

3.5. Transition of the database from development to implementation

One of the key constraints regarding the development of a database from first principles for the CAGES project is the limited experience of the project staff regarding the use and application of Access. Therefore it is recommended that transition of the database from development to implementation should be supported in order to ensure that the database continues to find application once the CAGES 2 component withdraws. It was hoped that before leaving it would be possible to review the revised CAGES database, including inputs from a John Bostock, with the new database manager in order to provide a reasonable transition from development to implementation. However, due to time limitations this has not been possible.

It is proposed that the database manager should receive support from a local trainer regarding the use and application of the revised database. The acquisition of suitable support materials e.g. relevant publications, training manuals, should also be considered in order to provide a valuable reference point and assist the manager of the database in developing their general database skills. In addition, the potential for future training within the CAGES 2 project should be considered.

4. Data collection

4.1. Constraints and opportunities identified during field visits

In order to assess the validity of data entered into the database, a series of spot checks was conducted with cage operators in the region around Jessore. In total four operators were questioned; however, due to limitations on the time that each farmer was able to spend answering questions the interviews were conducted at a relatively basic level. The first three farmers from Binodpur village convened at the Jagorani Chakra field office, which is situated, on the banks of the Nabagonga River; Jagorani Chakra is one of the NGOs working in the Jessore region. The forth interview was conducted with a participant who operates his cage in the Nabagonga River close to the village of Shealjuri. Summaries of the interviews conducted are contained in Appendix 3.

It appears that the NGO field-staff maintain a relatively good level of interaction with their participants, visits are conducted once or twice per month and where appropriate technical assistance is provided. It was apparent that the NGO field-staff play a key role in the collection and collation of primary data from the participants. In general the farmers interviewed relied on their memory for recalling details regarding the management of their cage systems; however, the NGO does not always collect new information relating to the participant during their relatively frequent visits.

It is suggested that NGOs are encouraged to collect general information relating to key management practices e.g. fish stocking, feed utilisation and fish harvesting, whenever they visit their participants. One potential role for the TO-ME&S would be to ensure that the NGOs implement some framework to coordinate this monitoring programme.

Once collected from the NGOs, staff at the field offices should ensure that the data sets have been entered in to the questionnaires correctly and that any missing or ambiguous datum are either recorded or verified before sending the complete data set to CBHQ. Assessing the accuracy of data supplied by participants to NGOs represents another important challenge, unless NGOs are keeping adequate records, it will be almost impossible to verify individual accounts from participants. However, the degree to which this affects the outputs of the project will largely depend on the types of indicator that are to be employed.

One method of validating information collected by NGOs would be for the TO-ME&S to observe or even participate in the data gathering procedure; however, this will have to be balanced against the other responsibilities that accompany this post. A simple approach to introducing accountability to the data collection process would be to develop a framework in which the life cycle of data within the cages project is outlined, from collection, to input into the database, through to analysis and reporting; assigning responsibility at each stage of the process.

Recent modifications to the socio-economic baseline survey have focused on more general indicators of wealth, education and status rather than trying to quantify everything. It may be possible to try and focus more on general indicators regarding the production data rather than asking participants to quantify inputs and outputs where records are not being kept. One key recommendation regarding the format of the production data survey is that some indicators regarding constraints, benefits and motivation are introduced. The question of risk assessment was raised in the 1999 Annual Review; however, to a large extent the assessment of factors contributing to mortality already gives a good indication of which risks affect certain producers. In this case, where risks have affected production it may be more beneficial to investigate this using a case study. Motivation on the other hand is a difficult factor to account for in the appraisal of production data, some participants may consciously not be managing their cages in order to optimise profits. Alternative strategies may be dependent on minimising financial risks, limiting exposure to external risks e.g. storms or poaching or balancing the management of the cage against other livelihood strategies. Constraints and benefits could also be assessed, lack of seed may constrain the participant from adopting an optimal stocking strategy whilst increasing social status may provide and added incentive to continue with cage aquaculture. However, unless questions relating to these factors are asked directly, it may be difficult obtain information on these underlying factors.
Appendix 1: Results from data interpretation using modified protocols developed during this project

Data from the 1998 growing season are currently available from 87 households (Hhs), representing 14% of the 632 Hhs participating in 1998. In total these 87 Hhs conducted a total of 142 culture cycles using 123 cages (Table 1). The average number of cages managed by a Hh was 1.4 and on average each cage is used in 1.2 culture cycles per year. Interestingly, those participants under the supervision of NGO 6 in District 2 each managed a single cage and were the only group who on average conducted more than one production cycle in their cages during the 1998-growing season. The remaining Hhs only conducted a single culture cycle in their cages, irrespective of the number of cages operated.

Table 1: Number of cycles conducted and cages used by participants under the supervision of different NGOs, the districts and thanas where these NGOs operate are also presented.

NGO	District	Thana	Households	Cages	Cycles	Cages/Hh	Cycles/Cage
2	11	Saturia	1	2	2	2	1
3	1	Savar	5	8	8	1.6	1
6	2	Chowgacha	26	26	45	1	1.7
7	24	Mohammadpur/ Sadar	13	14	14	1.1	1
8	22/2	Sadar	36	61	61	1.7	1
9	21	Kotchandpur	3	8	8	2.7	1
10	2	Avoinogor	3	4	4	1.3	1
Total			87	123	142	1.4	1.2

NB: Several entries referred to cages being used for second cycles, with no record for the performance of the cage during the first cycle and, in some cases, it was unclear whether a Hh was using a single cage for several cycles or employing more than one cage. In addition, there were two cases where there was a discrepancy between the household number used by an NGO to identify participating Hhs and the expected name of the participant. Where uncertainty existed, the most probable scenario was assumed; however, it is recommended that the new database manager should refer to the original data to clarify or remove anomalous entries prior to reporting the final project output from 1998.

Overall investment, management and performance for production cycles during 1998

Average values from all production cycles in the 1998 subset indicate that the mean volume of new cages (n=74) bought into production was 2.3m^3, with each cage having an average construction cost of Tk567. Depreciation on new cages, based on the average expected number of cycles possible before the cage requires replacement (10) was Tk57 cycle^{-1}. Based on the average expected life span of 3.6 years for cage constructed in 1998, the average rate of depreciation for new cages can be calculated at Tk158 y^{-1}. However, due to variations in the expected number of cycles and life span for cages with different construction costs, the actual average rates of depreciation per cycle and per year were Tk74 and Tk179, respectively.

During 1998, the average stocking number for each cycle was 439 fish, in some instances the fry died soon after being stocked, in this case the cages were restocked and the number of new fry added to the total stocking number for that cycle. The average stocking density for all cycles in 1998 was 133 fry m^{-3}, with an average fry weight of 5g. During the culture cycles an average of 23.2 kg of feed was supplied to each cage, the average daily feed ration was 371 g d^{-1}.

The average cost of fry to stock the cages prior to each cycle was Tk221, and the feed cost was Tk86 cycle^{-1}. The operators of cages in 1998 spent on average of 12 days working on their cages during each cycle, hired labour costs were on average low at Tk4, but this is due to the fact that labourers were only engaged in 3 of the 142 production cycles. No other costs were incurred by any of the cage operators. The average operating cost per cycle was Tk308; however, including depreciation on new and existing cages and the cost of repairing old cages, the average total cost incurred by cage operators was Tk469 cycle^{-1}.

At harvest the fish had increased in size to an average of 35g, an increase of 30g when compared with the mean stocking weight. Survival in the cages during the culture cycles averaged 84%, the proportion of the total loss due to stocking mortality, culture mortality, escapes, poaching and other causes was 17%, 40%, 27%, 13% and 3%, respectively. The average number of fish sent to market after each cycle was 319, an average of only 7 fish from each culture cycle were consumed and the use of fish cultured by the participants for other purposes were negligible. The average income generated from selling fish at market was Tk457 cycle^{-1} and the average value of fish consumed by the participants was Tk16 cycle^{-1}.

The average income generated from a culture cycle during 1998 was Tk474 and the average total cost to the operator was Tk469; therefore, the average profit generated from a single culture cycle was Tk5. The overall return on investment (ROI) was 1% for culture cycles conducted during 1998. The difference between these values and those reported in the 1998 Annual Review is a consequence of introducing depreciation values for cycles being conducted in cages purchased in 1997. The depreciation values used were the same as those estimated in 1997 and used in the financial analysis of production data from that year.

Performance by species

In total 16 species or combinations of species were stocked in culture cycles conducted during 1998, species 3 was stocked in the largest number of cycles (106), species 4 was stocked for 10 cycles, species 5 was stocked for 7 cycles and species 43 was stocked for 5 cycles. Species 2, 10 and 34 were stocked in 2 cycles and species 7, 8, 17, 35, 53, 324, 177 and 46 were stocked for only 1 cycle. Table 2 shows the average investment, profit and the ROI for the species groups cultured during the 1998-growing season.

Table 2: The average investment, profit and the ROI for different species groups cultured during 1998

Species	Number of cycles	Survival (%)	Total cost, Tk cycle^{-1} Mean (1SD)	Profit, Tk cycle^{-1} Mean (1SD)	ROI (%)
2	2	48	431 (11)	-206 (329)	-48
3	106	85	398 (261)	-6 (252)	-2
4	10	82	559 (172)	-39 (329)	-7
5	7	83	821 (226)	-82 (484)	-10
7	1	96	360 (-)	310 (-)	86
8	1	56	634 (-)	-132 (-)	-21
10	2	96	371 (10)	-71 (4)	-19

17	1	100	254	(-)	266	(-)	105
43	5	67	668	(116)	-148	(243)	-22
35	1	98	1234	(-)	836	(-)	68
53	1	95	1334	(-)	731	(-)	55
34	2	84	938	(76)	33	(47)	4
324	1	94	875	(-)	325	(-)	37
177	1	96	434	(-)	566	(-)	130
46	1	98	1197	(-)	555	(-)	46

The best performance, based on ROI, was obtained when species 7, 17, 35, 53, 324, 177 and 46 were stocked in the participants cages; however, in each instance only one cycle based on the culture of these species has been reported. This may indicate that culturing less common species represents a high potential strategy or that participants willing to experiment with different species manage their cages better than those participants who stock conventional species. Ultimately however, it is not possible to state that the culture of these specific species and species combinations represent a tried and tested method as the respective systems are only represented by one example.

Although on average species 3, 4, 5 and 34 generated a negative net benefit for their operators, the huge variation that is apparent in both the investment cost and profit realised indicates that the management strategies adopted by individual participants could play a significant role in influencing the performance of the system. The relatively large losses incurred when culturing species 2, 8, 10 and 43 appear to indicate that these species or species combinations may not be suitable for cage culture; however, such a judgment should be based on a much larger sample.

Performance of all species based on stocking density

Table 3 presents a brief summary of investment, profit and ROI based on the stoking density used in the culture cycle. The best ROI of 59% was obtained when fish were stocked at a density of between 200 and 249.9 m^{-3} in 1m^3 cages and a good return of 47% was obtained when fish were stocked at between 150 and 199.9 m^{-3} in cages with an average volume of 1.7 m^3. The only other positive ROI of 47% was obtained when low stocking densities of between 0 and 49.9 fish m^{-3} were employed in cages with an average volume of 9.4 m^3. It is interesting to note that participants employing larger cages generally employ lower stocking densities in their cages, one potential reason could be that the species being stocked in larger cages require more space; however, this would need to be verified with a more detailed examination.

Table 3: Investment, profit and return on investment for different stocking densities of all species

Stocking density (no. m^3)	Number of cycles	Mean cage volume (m^3)	Total cost Tk cycle Mean (1SD)		Profit Tk cycle Mean (1SD)		ROI (%)
0-49.9	17	9.4	563	(311)	263	(314)	47
50-99.9	50	9	631	(198)	-116	(304)	-18

100-149.9	14	7.5	725	(319)	-26	(420)	-4
150-199.9	21	1.7	230	(181)	109	(73)	47
200-249.9	30	1	166	(23)	98	(34)	59
250-299.9	-	-	-	-	-	-	-
300-349.9	2	1	394	(21)	-353	(16)	-90
350-399.9	6	1	566	(96)	-253	(117)	-45
400-449.9	1	1	552	(-)	-282	(-)	-51
450-499.9	-	-	-	-	-	-	-
500-549.9	1	1	797	(-)	-341	(-)	-43

Performance of species 3 based on stocking density

The number of culture cycles involving species 3 (n=106) is sufficiently large to assess the performance of this species when stocked at different stocking densities. Table 4 presents a brief summary of investment, profit and ROI based on the stoking density used in the culture cycle. In general it appears that stocking species 3 at low stocking densities (0-49.9) has the greatest potential to generate a large profit that represents a significant return on investment (123%); however, this finding is base on information from only 6 cycles. Intermediate stocking densities of between 150-199.9 and 200-249.9 fish m^{-3} also generate reasonable rates of return at 51% and 59%, respectively. None of the other stocking densities employed generated a positive rate of return.

One potentially influential factor is the level of investment, focusing on participants using lower stocking densities of between 0-149.9 fish m^{-3}. It is apparent that although the participants are generally using on average cages with the same volume, the participants spending an average of Tk349 and on stocking between 0-49.9 fish m^{-3} make a considerable profit whilst participants stocking between 50-99.9 and 100-149.9 fish m^{-3} spend an average of Tk640 and Tk599, respectively, fail to generate a positive ROI. This may indicate that minimizing expenditure on purchasing the cage can contribute significantly to the overall performance; however, other factors such as the type of species being cultured, stocking size, feed type etc. all have the potential to influence performance.

Table 4: Investment, profit and return on investment for species 3 at different stocking densities

Stocking density (no. m^3)	Number of cycles	Feed input g fish d^{-1}	Mean cage volume (m^3)	Total cost Tk cycle Mean	(1SD)	Profit Tk cycle Mean	(1SD)	ROI (%)
0-49.9	6	0.78	8	349	(29)	429	(139)	123
50-99.9	41	1.00	9	640	(193)	-162	(298)	-25
100-149.9	7	0.76	7	599	(235)	-27	(76)	-5
150-199.9	19	0.66	1	175	(32)	89	(39)	51
200-249.9	30	0.53	1	166	(23)	98	(34)	59
250-299.9	-	-	-	-	-	-	-	-
300-349.9	2	0.21	1	394	(21)	-353	(16)	-90
350-399.9	1	0.29	1	535	(-)	-273	(-)	-51

Performance of all species based on size of fry at stocking

The stocking of fish smaller than 4g, irrespective of species, does not appear to represent a good management strategy. Cycles where cages were stocked with fish smaller than 2g (n=2) generated a ROI of -90%, stocking fish with a mean weight of between 2g and 3.99g (n=39) also generates a negative ROI of -36%. Stocking fish between 4g and 5.99g (n=76) generated an average profit of Tk129 cycle^{-1}; representing a ROI of 41%. Although the ROI appears reasonable, the large standard deviation around the average profit indicates that there is considerable variation regarding performance in individual cycles.

Table 5: Investment, profit and return on investment for different fry size at stocking for all species

Size at stocking (g)	Number of cycles	Stocking density (no. m^{3})	Total cost, Tk cycle^{-1} Mean (1SD)		Profit, Tk cycle^{-1} Mean (1SD)		ROI (%)
0-1.99	2	94	699	(262)	-632	(167)	-90
2-3.99	39	151	612	(220)	-223	(253)	-36
4-5.99	76	148	312	(258)	129	(210)	41
6-7.99	16	73	683	(143)	-55	(173)	-8
8-9.99	3	67	645	(323)	255	(25)	40
10-11.99	4	34	649	(218)	-24	(531)	-4
12-13.99	1	25	1197	(-)	555	(-)	46
14-15.99	1	67	962	(-)	438	(-)	46

The largest mean capital costs of Tk1197 and Tk962 are also associated with stocking relatively large fingerlings between 12-13.99g and 14-15.99g, respectively. Although the cost of establishing these systems is considerable, this strategy realises a ROI of 46%; therefore stocking large fish appears to represent a high potential management strategy. One interesting point to consider is that the larger fish that are being stocked actually represent a particular species and it would be interesting to investigate this further.

Performance of species 3 based on size of fry at stocking

The affect of stocking size for species 3 follows a similar trend to that observed for all species; culture cycles where fish below 4g are stocked were, on average unable to realise a positive ROI. Stocking fish between 4g and 5.99g, which was done in 69 cycles, generated a mean profit of Tk105 cycle-1, this represents a ROI of 40%. Interestingly, stocking larger fish between 6g and 7.99g was unable to generate an average profit from 11 cycles; again the cost of establishing the systems appears to be influencing performance.

Table 6: Investment, profit and return on investment for different fry size at stocking for species 3

Size at stocking (g)	Number of cycles	Stocking density (no. m^{3})	Total cost, Tk cycle^{-1} Mean (1SD)		Profit, Tk cycle^{-1} Mean (1SD)		ROI (%)
0-1.99	1	63	514	(-)	-514	(-)	-100

2-3.99	24	101	663	(251)	-256	(248)	-39
4-5.99	69	154	264	(177)	105	(184)	40
6-7.99	11	84	623	(28)	-189	(139)	-30
8-9.99	-	-	-	-	-	-	-
10-11.99	1	63	654	(-)	156	(-)	24

Performance of all species based on cage volume

Cages with a volume of $1m^3$ generated an average profit of Tk31 $cycle^{-1}$, representing a return on investment of 13%. However, the large standard deviation (151) associated with the profit indicates a high degree of variability. The profits generated from cages with a volume of $8m^3$ just failed to cover the costs associated with one culture cycle, generating an average profit of Tk^{-2}. Cage culture in 12 m^3 cages was associated with an average loss of Tk293; however, culture in $32m^3$ cages generated the largest average ROI of 28%, but this is based on information from only two cycles.

Table 7: Investment, profit and return on investment for cages with different volumes

Cage volume (m^3)	Number of cycles	Stocking density (no. m^3)	Total cost, Tk $cycle^{-1}$ Mean	(1SD)	Profit, Tk $cycle^{-1}$ Mean	(1SD)	ROI (%)
1	60	220	233	(155)	31	(151)	13
8	74	69	595	(206)	-2	(339)	0
12	6	81	1013	(38)	-293	(494)	-29
32	2	41	1244	(66)	352	(287)	28

Overall investment, management and performance for Hhs participating in 1998

Overall the information for 87 Hhs is present in the 1998 database, as mentioned previously, the average number of cages managed by a Hh was 1.4 and the average number of cycles was 1.2 y^{-1}. Investment per Hh, based on an analysis of investment by individual households was Tk766, and the average profit generated by a Hh was Tk8 during 1998, which represents a ROI of 1%.

Performance of Hhs operating different numbers of cages

Households managing 1 cage made an average profit of Tk71, representing a ROI of 13%; however, the large standard deviation (331) associated with this level of profit indicates that there is a high degree of variability. The best average ROI of 63% is realised when 3 cages are managed by a Hh; however, as this is based on the results from only 4 households this is highly speculative.

Table 8: Investment, profit and return on investment for Hhs managing different numbers of cages

Cage number	Number of Hhs	Total cost, Tk $cycle^{-1}$ Mean	(1SD)	Profit, Tk $cycle^{-1}$ Mean	(1SD)	ROI (%)
1	42	534	(267)	71	(331)	13

2	39	852 (553)	-36 (433)	-4
3	4	663 (106)	415 (31)	63
4	1	2052 (-)	-1232 (-)	-60
6	1	6237 (-)	-1367 (-)	-22

Performance of Hhs associated with different partner NGOs

With the exception of NGO 7 and NGO 8, the Hhs working with the other NGOs indicated in Table 9, were unable to generate a positive average ROI. The best ROI of 68% was obtained by Hhs working with NGO 8, on average these Hhs also spend the least on their cages during a culture cycle. Therefore, this low input strategy may represent a promising approach to cage aquaculture.

Table 9: Investment, profit and return on investment for Hhs supervised by different NGOs

NGO	Number of Hhs	Total cost, Tk cycle^{-1} Mean (1SD)	Profit, Tk cycle^{-1} Mean (1SD)	ROI (%)
2	1	985 (-)	-479 (-)	-49
3	5	909 (649)	-474 (426)	-52
6	26	1089 (507)	-226 (474)	-21
7	13	712 (222)	221 (291)	31
8	36	353 (142)	239 (142)	68
9	3	2855 (2931)	-351 (880)	-12
10	3	753 (125)	-341 (354)	-45

Appendix 2: Analysis of the production data collected for the 1997 culture season

The data set for the 1997 culture season contains the records for 520 production cycles. However, as mentioned in the 1998 Annual Review several entries omit the value of fish that were marketed by the participants. It may be possible to enter appropriate values based on the number of fish sold, although not ideal it would at least increase the size of the data set that was available for analysis. Unfortunately during the majority of production cycles conducted in 1997, several different species were stocked concurrently in the same cage; therefore, attempting to assign values retrospectively would take a substantial amount of time and was not considered practical during this relatively short assignment.

Therefore those records that omit to mention the value of fish produced were excluded from the data set. Other records within the remaining data set were omitted from some analyses due to the absence of reliable key variables; in this case the number of cycles that form the revised data set is given. Common problems included the omission of harvest dates, negative figures for survival and obvious data input errors; where appropriate, minor errors were rectified.

The fact that participants stocked a range of fish in the same cage makes the analysis of performance of these production systems based on the species being cultured unrealistic. Another problem with the stocking regimes adopted by the participants during 1997 was that stocking was done on a number of separate occasions. Therefore, it is difficult to determine an appropriate approach to defining a stocking density that would allow comparison between management strategies and, as the majority of these stocking densities would be based on a mixed species composition the findings would be of limited value. Of the 520 production cycles recorded for 1997, 216 involved the stocking of more than one species in the cage. Therefore a subset of data from 1997 containing those records where the value of production from a cage stocked with one species was used as the basis for comparing differences between performance based on species and stocking density.

Removing records where no income had been specified but fish had been produced and where insurmountable problems were encountered resulted in the size of the data set being reduced from 520 to 349 cycles. Unfortunately, the absence of any household identifier within the data set meant that it was impossible to assess the relative performance of individual households. Participants during 1997 were primarily identified based on their name and sometimes only their first name, the next level of identification employed was the village name; therefore the process of linking production data and baseline survey information from 1997 to performance data being collected in 1998 represents a considerable undertaking. Attempting to link the limited data set available for 1998 with that from 1997 also demonstrated that in several instances the spelling of participants names were recorded differently. It would be beneficial to the project if the production data and baseline data from 1997 could be retrospectively linked with that from 1998 to give an indication of continuity within the project. The most promising approach may be to supply the NGOs with the details of participants in their respective regions during 1997 and 1998 and ask them to link the two.

Inputs, performance and ROI

The results presented in this section are based on the analysis of the subset of 349 valid production cycle records for 1997. The average cage size employed during 1997 was 9.5 m^3 and represented an average initial capital cost of Tk757. The participants expected their cages to last for approximately 6 production cycles giving a mean depreciation value of Tk141 $cycle^{-1}$. During 1997 none of the participants needed to spend money on repairing their cages; however, the average cost of seed, feed and labour for the cages was 793 Tk, Tk400 and Tk50, respectively, no other cost were incurred. On average participants stocked 1362 fish into their cages giving a mean stocking density of 155 m^3; feed was supplied to the cages at a rate of 95 kg $cycle^{-1}$ and participants spent an average of 39 d $cycle^{-1}$ managing their cages. Therefore, the average operating cost for a cage during 1997 was Tk1243 $cycle^{-1}$, including depreciation the total cost for operating a cage increases to Tk1385 $cycle^{-1}$.

The average duration of a single culture cycle during 1997 was 124 days, during this period the average feed ration supplied to the cages was 766g d^{-1}. Average losses from the cages were 519 fish $cycle^{-1}$, representing 38% of the fish initially stocked into the cages. Mortality during the culture period accounted for 45% of the losses, mortality just after stocking accounted for 18%, the escape and poaching of fish from the cages represent 25% and 2% of the losses, respectively, and the remaining 11% were attributed to other causes.

The majority of fish produced in the cages were sold at market, the average number of fish sent to market from each cycle was 466, only an average of 31 fish from a cycle were consumed by members of the participating households. These levels of fish selling and consumption represent an actual benefit of Tk1144 from selling fish and a relative benefit of Tk164 from not having to purchase fish for consumption. Therefore the average total income from a cage cycle during 1997 was Tk1308; accounting for the total cost incurred during the production cycle the average net benefit was Tk-76 $cycle^{-1}$. The average return on investment for during 1997 was -5.5% for the culture cycles considered in this analysis, and the average return to labour was Tk-2 d^{-1}.

Assessment of performance based on NGO

There is huge variation in the performance of Hhs under the supervision of different NGOs. The Hhs working with NGO 18 receive a substantial average profit of Tk1756 $cycle^{-1}$, representing a ROI of 117%. Hhs working with NGO 8 also receive a large average profit of Tk650 $cycle^{-1}$, a ROI of 170%. It would be interesting to see if the good performance of these NGOs is dependent on the technical assistance that they provide or a due to some other regional or environmental factor.

Table 10: The average investment, profit and the ROI for Hhs under the supervision of different NGOs

NGO	Number of cycles	Total cost, Tk $cycle^{-1}$ Mean (1SD)	Profit, Tk $cycle^{-1}$ Mean (1SD)	ROI (%)
2	33	1272 (762)	-197 (638)	-15
3	14	977 (119)	-244 (556)	-25
4	28	1728 (1377)	-345 (1756)	-20
6	17	827 (499)	298 (436)	36
7	30	802 (396)	-107 (430)	-13
8	9	383 (55)	650 (204)	170

9	20	1717	(744)	261	(732)	15
10	17	592	(404)	88	(363)	15
12	16	3568	(1710)	381	(2465)	11
15	6	1905	(716)	895	(1802)	47
16	15	2090	(686)	-1480	(1083)	-71
17	11	960	(242)	-38	(538)	-4
18	16	1505	(507)	1756	(1280)	117
19	22	1299	(410)	-1049	(338)	-81
20	20	973	(216)	-73	(542)	-8
21	16	2049	(594)	6	(1022)	0
22	25	1701	(574)	143	(1278)	8
23	10	1016	(447)	352	(945)	35
24	24	1050	(118)	-876	(80)	-83

Other potential analyses include comparing feed input with performance, comparing effect of multiple stocking against single stockings and assessing performance against investment. In addition, where a single stocking strategy has been employed it may be possible to compare the performance of different species. Md. Shahroz is intending to work on further analysis of the date collected from the 1997 culture season.

Appendix 3: Summaries of the participant interviews conducted in Jessore region

1130-1200, Jagorani Chakra, NGO field office, Binodpur

Md. Rashid Biswas cultures silver barb and feeds them rice bran, oil cake and whole rice; the feed is measured out in a plastic container which holds exactly 0.5 kg, at the end of each month the amount fed is calculated based on the average number of measures supplied each day. Md. Biswas stated that in addition to being profitable that cage aquaculture was enjoyable.

Md. Shawkat stocks his cages with prawns between 10g and 15g, within two to three months the prawns reach a size of between 50g and 60g. One problem encountered by Md. Shawkat is that of predation when the prawns are moulting, now that he realises this problem he introduces branches to his cages when the prawns are moulting in order to provide shelter and refuge for the vulnerable prawns. Md. Shawkat is also a prawn trader and each day purchases 30 kg of prawns from local farmers and sells them on at the local depot.

Md. Karamoth Ali cultures prawns and silver barb; the prawns are stocked at a rate of 100 pieces in each of his 8 m^3 cages; the prawns stocked into the cage were caught in the river using a trap. Md. Ali reported that mortality in his cage was extremely low with only one fish being lost in the last culture season. Md. Ali's cages are situated close to the Jagorani Chakra field office and he was kind enough to invite us to see them.

In general the participants were pleased with cage aquaculture and suggested that other farmers in the village had expressed an interest in cage aquaculture.

1300-1330, homestead on the banks of the Nabagonga River, Shealjuri

Md. Biswanath, operates three cages in the river close to the village of Shealjuri. In total three cages are operated and they are stocked with a polyculture of prawn and *Labeo calbasu*. Last year the cages were stocked with grass carp but owing to an infestation of parasites the performance of this system was limited. Now that Md. Biswanath is culturing prawns he is satisfied with the system, but has no plans to expand his enterprise. Juvenile prawns are collected from the river and stocked into the cages; however, Md. Biswanath has only been able to collect between 300 and 400 juveniles and therefore has purchased approximately 600 juveniles from other sources. When asked about problems with cannibalism, Md. Biswanath thought that this problem was associated with the full moon and that if he did not give more feed at this time then cannibalism would occur.

The collection of snails for feed is done by Md. Biswanath's three young sons, on average his sons spend between 1 and 2 h d^{-1} collecting snails whilst playing close to the river. Md. Biswanath spends an average of 1 h d^{-1} managing his cages and does not feel that interferes with his normal work as a fisherman. In addition to feeding snail meat, the prawns also receive wheat and coconut. Apparently other people in the region are interested in cage aquaculture but they are not fishermen. Like the other participants interviewed at Binodpur, Md. Biswanath is visited by an NGO worker between once and twice per month, sometimes more, and gives advice. The NGO worker also makes a note of recent activities; in common with the other participants Md. Biswanath does not make notes but remembers most of the details relating to the management of his cages.